Research of Module Construction Based on Integration Theory

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Abstract—**This article reviews literatures on module theory by highlighting some of the conceptual issues. Based on integration theory and system theory, it discusses the significance of module construction for integration management and identifies the three main factors that are critical in the module construction process. After introducing the concept of "integrated internal force", an integrated model is proposed, which synthesizes the factors of system function and then can be used to evaluate the overall function of a whole integrated system. Further, this article puts forward the ideas and policy suggestions of module construction from three aspects in end, so as to assure the quality of modules in integration management.**

Keywords- *integration theory; system theory; module construction*

I. INTRODUCTION

The discussion on module theory can be traced back to H•Simon's study in 1960s. He explored the dynamic properties of hierarchically-organized systems, and showed how they could be decomposed into subsystems in order to analyze their behavior. He addressed that a complex system was made up of a large number of parts that interacted in a nonsimple way. In such systems, the whole was more than the sum of the parts, not in an ultimate, metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their interaction, it was not a trivial matter to infer the properties of the whole. In the face of complexity, an in-principle reductionist might be at the same time a pragmatic holist (H. A. Simon, 1962). Not only have computer companies transformed a wide range of markets by introducing cheap and fast information processing, but they have also led the way toward a new industry structure that makes the best use of these processing abilities. At the heart of their remarkable advance is modularity-building a complex product or process from smaller subsystems that can he designed independently yet function together as a whole. Through the widespread adoption of modular designs, the computer industry has dramatically increased its rate of innovation. Indeed, it is modularity, more than speedy processing and communication or any other technology, that is responsible for the heightened pace of change that managers in the computer industry now face. And strategies based on modularity are the hest way to deal with that change (Baldwin and Clark, 1997). In 2003, Masahiko Aoki addressed that module was a semi-self-discipline subsystem that could be composed of a system and it also could be made into a more complicated system or process, besides, he revealed the significance of modularity concerning industrial structure evolvement. After that, the study of module theory aroused wide attention from scholars, and then it has gradually become a hot issue of interdisciplinary research.

The theory is also modified and supplemented by some other scholars. Ernst(2004) pointed out that the modularity had its own limitations, including over-demanding of coordination, constraints of interface standard, slowing down of innovation, it also caused the problem that technology modularity, organization modularity and marketing modularity were not able to be naturally converge；Yan Xingyu and Gao Juemin (2007) pointed out that modularity couldn't become a ultimate steady-state because there were still many deficiencies about modularity and it lacked of internal coordination advantages, it was hard to decide which one to choose, integration or modularity. The decision should be made based on the gap between the technology and consumer needs. Integration is preferred when the industry performance is unsatisfied, while modularity is preferred when it's in a good condition. We should recognize that, although there are still many defects in the module theory, especially its scope of application, its main ideas, methods and basic conclusions are worth considering.

The integration theory and system theory are widely used in the human society system. System is the result of elements integration, while integration is the basic activity to construct a system. As the old saying goes, "There is no cooperation without the same ideological concepts", or "Birds of a feather flock together", they are both manifestations of integration, it's implied that there should be some prerequisites for integration. Wu Qiuming (2004) argues that integration is a collection of some elements with common property, i.e. it's necessary for the objects of integration to own common properties, including objectives, functions, requirements, or other internal and external properties. The integrated module is the basic element of an integrated system. However, it can be a big problem for the managers to select and build the integrated module, for the purposes of assuring the quality of modules and multiplying the function of an integrated system.

Therefore, this paper studies on module construction based on the integration theory and the system theory.

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II. THE SIGNIFICANCE OF MODULE CONSTRUCTION FOR INTEGRATION MANAGEMENT

A. The three results of integration

Wu Qiuming(2003) pointed out that when we built a system, we usually tried to enhance the function and effectiveness of the system by means of combination of elements, arrangement of structure, optimization of relationship, so as to achieve the goal of "1+1> 2". However, it seems that things do not turn out as someone wishes. In real life, many things are not always going as smooth as we expect. A lot of facts prove that the effect of "1 +1> 2" or the emergence of new functions is not the only result of integration. In fact, there are three possible results of integration:

First: 1+1> 2, i.e. non-linear growth of function, by which we call it Superior Integration;

Second: 1+1=2, i.e. simple addition of function, by which we call it Ordinary Integration;

Third: 1+1<2, i.e. loss of function, by which we call it Inferior Integrated.

Therefore, there's difference between the results of integration and its elements. The results of integration usually go by the name of the whole emergence. When it comes to three results of integration, the second one is an embodiment of addiction (zero-emergence), it indicates that the whole is equal to the sum of its parts. While the first and the third one are embodiments of non-addition, i.e. the whole isn't equal to the sum of its parts (the first one is looked on as positive emergence while the third one is negative emergence).

When we implement the planning, organization, leading, coordinating, controlling toward the activities of integration, in fact, we are being engaged in the job of integrated management. Also, when we try to make integration into superior integration, actually we are striving to achieve the goal of multiplying the function by means of integrated management. Therefore, because of the three possible results of integration and the uncertainty of superior integration, it's necessary for us to study on integration and its principles, and then establish the theoretical framework of integrated management.

B. The three main factors of the overall function of integrated system in the process of integrated management

So, what is the definition of function? What is the function of system? What are the main factors that affect system function? How to realize the goal of multiplying the function of system in the process of integrated management? All these problems are inevitable when we study the theory of integration management.

In Chinese, function refers to credit, merit, efficiency, capability, i.e. the system provides goods and services to the other objectives in the environment by virtue of their resources and capabilities, in order to be helpful to the objectives' survival and development. Every system has its own function, and it's a common property for system. The function of system emphasizes the Principles of Integrity. We should pay more attention to maximizing the overall interests rather than maximizing the individual interests.

According to system theory, the integrated characteristic and function (F) of a system is affected by components (C), structure (S), environment (E). It can be described as (1):

$$F = f(C, S, E) \qquad (1)$$

Equation (1) is also known as the equation of system condition, which reflects the integrity principle of the system as a whole. Then it can be further inferred that the function of system depends on the interconnection of components (C), structure (S), environment (E). In (1), F represents a nonlinear function. So, for an integrated system, how to quantitatively define the relation between the overall function and the three factors?

According to the integration theory, in the social system, there exists certain integrated internal force during the integration process of two "non-ultra distance" modules or units (they don't act on each other directly), the integrated internal force can be described by the following model [1]:

$$F(t) = E(t)\,\frac{Q_1(t)Q_2(t)}{d^2(t)} \qquad (2)$$

In (2),

F(Force)—F represents the integrated internal force between the two integrated modules in social system ;

Q_1,Q_2(Quality)—They represent the qualities of two integrated modules in the social system respectively, e.g. the qualities of individuals, groups, organizations combined in different way;

d(distance)—d represents the psychological distance between two integrated modules of social system,

E(Environment coefficient)—E represents the environment coefficient（E>0）. We assume that: in a simple environment, e = 1; while in a complex environment, E<1; the more complex the environment is, the smaller the quantitative value of E will be.

T(time) —T represents the time parameters. In the system of human beings, quality, psychological distance and environment coefficient are all affected by time parameters; they vary with the time going. It's different from the natural system. There's a specific quantitative value for those variables at a specific time point.

In order to give further description of (1), (1) and (2) should be both taken into consideration. The overall function of an integrated system should be measured on the basis of the integrated internal force. The greater the integrated internal force is, the better the overall function of integrated system will become. According to the basic viewpoints of module theory, the object of integration should be integrated modules, which are also components or integrated units that are mentioned above. Although the integrated system may include more than two integrated modules, only if we examine the integrated internal force between any two integrated modules, we can evaluate the integrated internal force of a whole integrated system.

Firstly, in order to improve the universality and generality of the formula, we assume that there are n integrated modules in one integrated system, then the first influencing factor(Components, i.e. C) can be represented by $Q_i(t)$（i＝1，2，……，n）, it implies the different qualities of different integrated module.

Secondly, the second influencing factor (Structure, i.e. S) can be represented by $d_j(t)$ (j＝1，2，……，m), it signifies the friction and loss of interface between any two integrated modules. It has a negative relationship with the matching degree or structured degree between different integrated modules. In which, j refers to the possibilities of any combination of two integrated modules within the integrated system. According to the basic principles of permutations and combinations, m can be formulated as (3):

$$m = C_n^r = \frac{P_n^r}{r!} = \frac{n!}{r!(n-r)!} \tag{3}$$

Finally, the third influencing factor (Environment, i.e. E) can be represented by E, it implies the environmental adapting ability of integrated modules at a specific time point or a certain period. The stronger the environmental adapting ability is, the bigger the value of E will be.

In this way, an integrated model, just as (4), can be proposed, which synthesizes the existing factors mentioned above and then can be used to evaluate the overall function of a whole integrated system.

$$F' = \sum F_j \tag{4}$$

In (4),

$$F_j(t) = E(t)\,\frac{Q_1(t)Q_2(t)}{d^2(t)} \tag{5}$$

$$m = C_n^2 = \frac{P_n^2}{2!} = \frac{n!}{2(n-2)!} \tag{6}$$

The management apocalypse that it brings to us is as follows:

For an integrated system, in order to implement better integration management, on one hand, we should have appropriate integrated modules (i.e. the object of integration). On the other hand, the integrated units should be designed and arranged according to a proper structure. Only in this way can we implement the integration toward the related units based on the practical environment condition and the needs of the system. Therefore, as an effect of whole emergence of a system, the function is determined by three factors (i.e. Components, Structure and Environment). They are equally important and none of them can be dispensed. In other words, the effect of module, the effect of structure and the effect of environment together determine the overall function of the integrated system. The integrated module is the most fundamental factors in the three factors. According to the viewpoints of module theory, if we are able to implement integration toward the Components based on the actual environment conditions, there will be a good guidance and direction toward the results of integration. Therefore, the construction of integrated modules tends to be a burning problem during the process of integrated management.

III. The Module Construction Based on the Mechanism of Integration Management

According to the viewpoints of complex adaptive system theory, the system components own the initiative and adaptability, which can be named agent based on the concept of economics. A more complete description about it is adaptive agent. The force of integrated system can be classified into two categories: internal force and external force, in accordance with the different resources of the force. The internal force comes from the inside of the agent, while the external force comes from the outside. In short, it depends on where the organizational command and the organizational strength come from.

Combination with (3), we describe the overall function (i.e. F) of the integrated system from two angles:

Firstly, from the perspective of external force, it should be emphasized on the abilities of environmental adaptive and self-adaptive (i.e. E (t) ↑); Secondly, from the perspective of the internal force, it should be emphasized on the specialized construction and integration construction of integrated modules.

In general, the construction of module under the mechanism of integration management should be carry out according to a certain steps, that is, system designing, the specialized construction of modules, the integration construction of modules. Just as follows:

A. System designing according to the environmental conditions (E (t) ↑)

According to the viewpoints of complex adapting system theory, to some extent, the integrated modules can be looked on as system components and adaptive agents. When it comes to the characteristics of initiative and adaptability, a further description is given as follows:

Firstly, the characteristic of initiative implies that the internal force play a leading role toward the agents. As a integrated module of adaptive agents, the characteristic of initiative can be proved by self-agglomeration, rather than being left alone. Only if there exist a lot of adaptive agents and integrated module, they always tend to speedily gathered. Assembling is one kind of interconnection; an amount of integrated modules tend to found out the suitable way for them to integrate, and then a certain structured integrated system is formed.

Secondly, the adaptability of the integrated module indicates that the external force plays a leading role in the behavior of agents, which tend to adapt to the environment. According to the complex adapting system theory, the relation between adaptive agents and environment is described as relation between stimulus and response. Stimulus implies that the environment has an effect upon system, while response implies that the system reacts to environment. The stimulus-response model is essentially a method of black box. It implies that we look on the integrated module itself is as a black box, and then we pay more attention on the issues of input and output. This method is based on the theory of complexity theory; it is helpful to simplify the problem and thus helps to work out effective ways to solve the problem. In the external environment of integrated module, there exist both adaptive agents (i.e. other modules remain to be integrated) and non-adaptive agents. We can take natural environment as an example for non-adaptive agents. It's impossible for natural environment to adjust or alter itself to adapt to the integrated modules. While, it has no choice to face and tackle the challenge comes from high demanding of adaptive agents, including demanding of resources and discharging of waste. In return, the challenge will have both positive and negative effect on the adaptive agents living in the environment. Therefore, environment has an essential role upon system. It's necessary for us to adapt to and take the good advantage of environment when designing the integrated system, instead of trying to altering the environment. Only in this way can we achieve the goal of improving the value of E(t) （i.e. E(t) ↑）.

B. Specialized Construction of Functional modules ($\sum Q_i (t)$ ↑)

During the process of modules construction, after finishing the system design (including the functional design of modules), the construction of integrated modules needs to be carried out according to a certain sequence, that is, firstly specialized building and then integration building.

The specialized construction of integrated modules implies that the design of functional interface is scientific and the function is specific, both of which are able to self-adjust constantly and improve the level of specialization, so as to improve the level of collaboration between them and other integrated modules. Meanwhile, the value of Q (quality of integrated module) is also increased, so as to have a positive effect on integrated internal force of an integrated system.

C. The integration of modules: integration construction of modules (d (t) ↓)

The next step of specialized construction of modules is the integration of modules, in other words, integration construction of modules. It emphasizes the selection and integration of different integrated modules, in order to achieve the goal of synergistic effect by integration. The factors that should be taken into consideration are the collaboration between different interfaces, the efficiency of integration, etc. The better the collaboration is, the higher the integration efficiency will be. It implies that the smaller the loss of interfaces is, the greater the overall function of integrated system will have.

Human beings have always been misunderstanding the specialized construction and integration construction of integrated modules. They prefer to believe that it's a wrong behavior to go after both of them, because it's not a wise choice to pursue something "large and all-inclusive" and "small as well as comprehensive". Actually, it's high time for us to carry out integration toward different modules based on the needs of system function and a certain principles, so as to form an integration system, which is so-called real specialization and integration. Of course, when the available function of integrated system can't meet the needs, we should further enhance the professionalism of modules within the system, besides, we should seek for resources that can be integrated and used outside the system. In this case, specialization and integration are constantly alternating; they can change into each other under given conditions.

CONCLUSION

Based on integration theory and system theory, this article discusses the significance of module construction for integration management. Further, it proposes an integrated model to evaluate the performance of an integrated system. The model is useful for situations where several modules need to be made up into an integration system. Currently, Superior Integration is not the only result of integration. Having tools and methodologies such as the one proposed can help industries, managers, brokers, etc. develop a toolset to more effectively manage in these types of environments. Therefore, this article puts forward the ideas and policy suggestions of module construction from three aspects in end.

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