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A Self-organization Analysis of Knowledge Collaboration with Enterprise 2.0 Application

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Abstract

The development of Web 2.0 and its social application lead to the appearance of Enterprise 2.0. Based on the discussion of self-organization of enterprise knowledge system in Enterprise 2.0, this paper built a super-network model integrated the interpersonal network and the knowledge object network as well as the definition of the super-network structure entropy. Take the knowledge governance as a regulator variable between enterprise knowledge system and its environment, a relationship between the performance of knowledge collaboration and structure entropy has been built, then a Logistic Growth Model has been proposed to analysis the self-organization process.

Keywords: *Enterprise 2.0, Knowledge collaboration, self-organization, super-network model*

1. Introduction

In an enterprise knowledge system, information flows in a *narrow channel* traditionally (McAfee, 2011). According to the limit capability of information and knowledge processing of any single node in this channel, the knowledge transfer may be paused or delayed. A reasonable inference is that, there may be very important information or knowledge had not been transferred appropriately in time. Former researches on knowledge management normally focus on the form exchange, influencing factors and management measures in the knowledge processing. The basic research modes are also restricted to the channel structure. A new mode, which studied in this paper, collaboration knowledge processing have not been supported adequately by technology and theory.

To put the right information and knowledge to the right people at right time and right site, is the goal of knowledge collaboration research. There are many successful social collaboration cases in web 2.0 environments, such as FACEBOOK, Wikipedia and so on, which are all typical knowledge collaboration pattern. Accompany with the wide application of web 2.0 technologies in enterprise Intranet or Extranet, enterprise knowledge collaboration which so called *Enterprise 2.0(E2.0)* is becoming our hot topic now.

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2. Literature Review

2.1. Enterprise 2.0 Application and Its Research

All Enterprise 2.0 as a concept subsumes the efforts of adopting social software, originating from the public Internet, for use in enterprise contexts and for professional purpose (McAfee 2006). McAfee defines Enterprise 2.0 as "the use of emergent social software platform within companies, or between companies and their partners of customers". E2.0 isn't just about applying social software, but it describes a wider approach that advocates a new culture of participation, inclusion, and sharing. Researches in this domain are most focus on Mashup system platform (Michele, *et al.*, 2010), governance structure (Mckeley, *et al.*, 2003) and their application. In China, the advantages of Web 2.0 technology had been discussed, and the characteristics of highly interaction, openness, flexibility, applicability and integration of web 2.0 have been considered as powerful weapon for knowledge acquisition, knowledge organization and sharing, then fostered the implementation of Knowledge Management (KM) system.

Enterprise 2.0 oriented to agile cooperation and knowledge sharing, advocate bottom-up management idea, decentralized management mode, flatter organization structure and widely customer participation. So it has a quite excellent capability widely used to acquire tacit knowledge, best practice and relevant experience in enterprise. To applied E2.0 into KM, those faults, such as limited usage of knowledge resource, low participation of whole staff, slow knowledge renewal, lack knowledge exchange and difficulty to meet personal requirement, could be make up in KM practice(Wang, *et al.*, 2007). Otherwise, E2.0 is only a technology application pattern, and technology alone will not guarantee an organizational success for any investment in IS. Realizing the objectives of a software implementation depends heavily on how the organization and its constituents will interact with the given technological artifacts and sustain the use thereof within the fabric of the enterprise. It is well established in the IS literature that the most ambiguous, yet critical part of realizing the aspired benefits from an IT investment is providing for the right organizational complements to the technology(McAfee,2006). So, there are many works to do in knowledge governance and management layer.

2.2. Knowledge Collaboration

Karlenzig (2002) proposed the concept of Knowledge Collaboration (KC) at first. He considered it as a strategic organizational approach that dynamically builds upon internal and external systems, business processes, technology and relationships (communities, customers, partners and suppliers) to maximize business performance. KC demonstrates the extent to which a corporation has institutionalized processes for knowledge creation, capture, sharing and reuse as a fundamental means of creating value. These capabilities produce the greatest value when they are embedded in the fabric of an organization's culture, values, processes and reward systems. Corporations that want to succeed in the networked economy need to master knowledge collaboration. After that, other scholars defined KC as a knowledge activity (Mckelvey *et al.*, 2003), organization capability (Glogel *et al.*, 2006) or management mode and strategy means(Fan,2007) at the firm level, and as a special relationship pattern at the industry or supply chain level (Yang Lijun, 2011). Tong (2011) defined KC as a multidimensional dynamic process, in which all these factors, involves subject, object, environment of KM, interact to a highly synergy situation, so that the right knowledge or information can be transferred to right object just in time. So it is a highly

development phase of KM to integrate knowledge resources and flows. Based on the definition of KC, most researches in China focus on the process analysis of KC up to now (Table 1). And with this table, we can conclude as follows: firstly, KC aims at knowledge creation, that's means there should be new knowledge produced at the end of KC. Secondly, KC contains many kinds of knowledge transforms, such as knowledge sharing, transfer, internalization and externalization. Thirdly, in the process of KC, there are sub-processes like knowledge searching, knowledge transfer and creation.

Table 1. Literature Review of KC Process Study in China

Author	Process of KC	Remark
Zen Deming, WenXiaoke et al,(2010)	Knowledge achievement, transfer and creation to get new knowledge	Supply chain level
Wang Congying,Guan Xiaodong(2009)	A closed-loop process of discovery, innovation, dissemination, and re-discovery.	Industry cluster
Tong Zehua (2012)	Contains requirement of KC, define subject of KC, activity of KC, achievement of KC and so on	Base on process
Shi Huibin (2008)	A 4-tuple process model of KC: environment,activities(relevant, reconstitution, integrate, collide, interact, share), knowledge flows（transfer/transform, internalization/ Externalization）and Goals	
Wu Shaobo et al(2008)	Knowledge sharing/transform/KM/knowledge creation	
Wang Yue(2009)	The core processes of KC are knowledge achievement, discovery, processing, dissemination and sharing, use and innovation.	

KC needs highly technology supportment, such as online knowledge-database or CSCW, to support its running (Lauric *et al.*, 2006; Anklam, 2002; Tian, 2003). Zhan *et al.* (2002) constructed collaboration knowledge management system based on network for staff and customers to exchange/sharing knowledge in distributed space. Chen (2005) considered that Wikipadia is a whole new platform for cooperate work and knowledge sharing in Internet era. Su (2006) introduced collaboration concept to knowledge innovation, and thinks that BLOG can be a new platform for knowledge innovation. It is obvious that the emergent of web 2.0 application pushed up KC practice as well as relevant research in management theory.

2.3. Research of Enterprise Knowledge System and Its Self-organization

KC is an evolution status of knowledge system. Research demonstrated that knowledge, as the main factor of enterprise knowledge system, has bionic properties (He, 2008), and enterprise knowledge system is an activity system with biological feature. This kind of system has anti-entropy increase mechanism which can improve degree of order to be a highly order structure. A knowledge-based organization is a

typical self-organization system with attributes of openness, non-equilibrium, nonlinear and fluctuations (Peng, 2005). Through the evolution process of enterprise system, external or heterogeneity knowledge can decrease system entropy and put system to a higher order structure.

Wikipedia and Baidu-Baike are self-organizational systems in web 2.0 era (Dan & Zhao, 2009; Song *et al.*, 2010). Enterprise wikis, microblog and virtual community in E2.0 application are main parts of enterprise knowledge system and have web 2.0 applied attributions, so they are self-organization knowledge systems. Voluntary cooperation can produce in E2.0 environment. If a demander has knowledge requirement, this information may be spread through web 2.0 platform among social network; a provider who own right knowledge for this requirement and fortunately in this network could meet this demand depend upon his interest. Based on the E2.0 platform, the self-organization feature of enterprise knowledge system makes an openness, dynamic and constant evolution knowledge forest for knowledge staffs to find problem, to analysis and solve it with rich and widely communication. So to speak that E2.0 enables staff to turn potential relationship of knowledge cooperation to real relationships and make tacit knowledge transfer into visualization knowledge collaboration.

But how can the enterprise knowledge system achieve synergy effect to fit organization strategy goals in E2.0 environment? Different with Wikipedia and BLOG on World Wide Web, E2.0 as a concept subsumes the efforts of adopting social software, origination from the public Internet, for use in enterprise contexts and for professional purposes (McAfee 2006). As the social software phenomenon is very closely connected to the unique culture of user participation and bottom up emergence typical for Web 2.0, transferring the phenomenon from the public Internet to the corporate context requires a good understanding of the phenomenon and its manifestation in different technical platforms. We will refer to the phenomenon of SNS (Social Network System)-base social networking in enterprise contexts as Enterprise Social Networking (ESN), a “Enterprise + social network” paradigm. In this article, a super-network model which comprise of interpersonal network and knowledge-object network should be constructed to represent the Enterprise Knowledge Network (EKN) with defined network structure entropy to measure system-order. Then a self-organization analysis has been carried out based on the entropy model and gotten some conclusions valuable for enterprise KM.

3. The Super-network Structure of EKN and Its Order Measurement

3.1. The Super-network Structure of EKN

Karl Popper had proposed three worlds theory: World 1(Objective World), being the physical world, or physical states; World 2(Subjective World), being the world of mind, or mental states, ideas, and perceptions; and World 3(Knowledge World), being the body of human knowledge expressed in its manifold forms, or the products of the second world made manifest in the materials of the first world (*i.e.*, books, papers, paintings, symphonies, and all the products of the human mind). There are some cognition relations among three worlds, indicated in Figure 1.

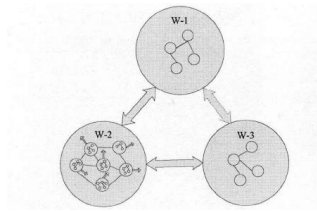

Figure 1. Mapping Relations of World 1, 2, 3

KM thinks that Enterprise Knowledge System contains all those knowledge factors around human resource in enterprise. There are mainly two kinds of factors, one is staffs corresponding to World 2(W-2) and another is knowledge objects expressed in vary medias (such as Enterprise BLOG, wiki, or virtual forum) corresponding to World 3(W-3). W-2 produced W-3, which is the explicit expression of the knowledge collaboration result produced by individuals. Conversely, W-3 affected the evolution of relationship and structure of human network in W-2. The self-organization process of knowledge system reflects the co-evolution process of W-2 and W-3. Therefor a collaboration model combined two layer networks of W-2 and W-3 under the definition of super-network system with interpersonal network and knowledge objects network should be proposed as below.

Let S denotes this super-network, N_k is the network set in which $k = 1, 2$, then $S = (N_1, N_2)$ means there are two network in this super-network, which are interpersonal network N_1 and knowledge objects network N_2 respectively.

Definition 1 Each network N_k $(k=1, 2)$ in super-network S can be expressed as $G_k = (V,E_k,L_k)$, in which V is a node set contained all nodes in S and $E_k = (e^k_{ij})$ is an edge set contained all edges in S. $L_k = (l^k_{ij})$ $(i=1,2,\ldots,n; j=1,2, \ldots,n)$ are weights of edge e^k_{ij} in N_k, which means the weight of information flow in network.

Flows in network can be quantified in vary ways base on network characteristic. Normally, the edges are un-weighted while researching on knowledge transfer among interpersonal network based on SNA. In this case, edges may be only reflect whether there are relations between two neighbor nodes but have no information about relation strength of knowledge transfer. Our super-network model has an important characteristic which made up this disadvantage by statistical analysis based on knowledge objects network N_2.

3.2. Definition of Network Structure Entropy

From the research achievement on self-organization evolution of knowledge network in web 2.0 environment, it is an ordering path, which is from un-order to ordered, from equilibrium state to un-equilibrium state, with state mutation or emergence by accidently, for a knowledge system evolution. In the system theory, entropy is an antithesis concept of degree of order, which is regarded as the core index of system evolution providing a measurement possibility of the degree of order. Hence, we should define the network structure entropy to express the evolution state of enterprise knowledge system.

Abstract the network as graph $G= (V, E,L)$, in which V is a node set, and E is an edge set, as well as $L(i, j)$ represent an edge from node i to node j. Consulted the definition of network structure entropy from articles of *Tan(2004)*, we define the important degree of node i or edge j as

$$I_i = \frac{k_i}{\sum_{i=1}^{N} k_i}, \quad J_j = \frac{L_j}{\sum_{j=1}^{M} L_j} \tag{1}$$

In which, N is the number of node, M is the number of edge, k_i is connectivity of node i, and L_j is the weight of edge j.

Then we can define Network Structure Entropy (NSE) as

$$E = -(\sum_{i=1}^{N} I_i \ln I_i + \sum_{j=1}^{M} L_j \ln L_j) \tag{2}$$

Regardless of enterprise knowledge object network such as BLOG and wiki, or interpersonal network, higher degree of knowledge network order means more effective of knowledge transfer or sharing, more possibility to achieve knowledge collaboration. With the super-network S of knowledge system, We appoint E_1、E_2 and E_S as the NSE of interpersonal network, knowledge object network and super-network itself respectively. If we can calculate all these NSEs on varies moment, then the degree of order of whole network, and change state of interpersonal network or knowledge object network should be measured more accurately.

4. Self-organization Analysis of Enterprise Knowledge Collaboration

4.1. The Self-organization Analysis Model of Enterprise Knowledge System

Relative to biology self-organization, it is mostly a domestically driven process for economic self-organization. The conscious and proactive behaviors of economic system help itself to gain new knowledge and techniques, to protect it from system inertia, such as energy/entropy constraint or history constraint. In knowledge system, this kind of conscious and proactive behavior can be called *knowledge governance*, which on behalf of conscious knowledge actions simulated and induced from factors outside, such as pressure of competitors, progress of basic science and change of law system. Knowledge governance are those actions, such as building knowledge exchange environment, setting up knowledge share culture and formulating knowledge transfer excitation mechanism, can affect relations between W-2 and W-3 to promote knowledge ecological system development. Thinking super-network as knowledge system itself, knowledge governance is a kind of regulation power acted on the system and determined the self-organization evolution process.

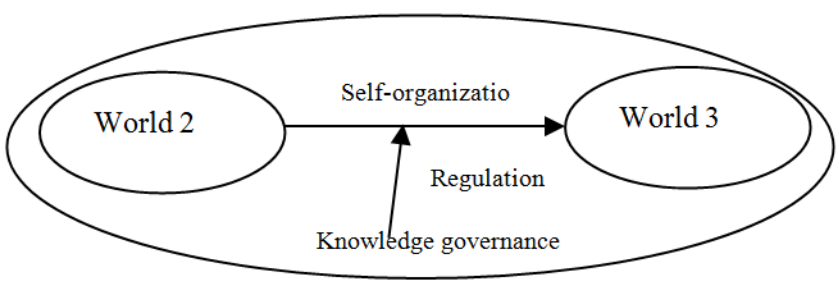

Figure 2. Enterprise Knowledge System Self-organization and Governance

Assume that $H=(H_i, i=1,2,\ldots,n)$ as an action set of knowledge governance, which mainly are systems, rules and orders. The structuring or ordering process reflected in the value change of NSE. Generally, knowledge governance results the entropy

decrease of knowledge system to offset the entropy increase resulted by knowledge system itself, then the entropy of whole system is reduced. Suppose the knowledge entropy equation of openness system as

$$R=R_H-R_k \tag{3}$$

In which R_k is the knowledge entropy produced by system itself and normally is positive value, R_H is the knowledge entropy produced by interaction of system and its environment and reflect the affection degree of knowledge governance applied to knowledge subject's motivation and behavior. R is the structuring degree of enterprise knowledge system, which can be measured by calculating NSE E of super-network S.

Meanwhile, define P as the performance of enterprise knowledge collaboration which reflects the matching degree of knowledge system structuring degree and enterprise performance currently, as well as the achievements of knowledge governance. Then P can be considered as the function of knowledge entropy:

$$\mathrm{P} = F(R) = F(E) \tag{4}$$

4.2. Self-organization Analysis of Enterprise Knowledge Collaboration

An endogenous structuring process should be impossible a deterministic convergence process towards a stable equilibrium state (Kurt,2011). Prigogine & Stengers (1984) point out that if we adopt a growth homogenous measure to measure structuring process, then the endogenous structuring process should be present as a special trajectory with time gone. This trajectory can be indicated by *logistic* diffusion equation which present as *S* shape and will approach to static state on boundary.

4.2.1. The Logistic equation of Enterprise Knowledge System Evolution: The Logistic equation is a deterministic math equation which usually be used to express relationships among economic variables and to distinguish all kinds of powers acted on the system exchange process from a static state to a new static state. But the self-organization process is a kind of unbalanced endogenous process, and the trend of approach to instable structure can't be exactly reflected in *Logistic* function. However, if the research goal is not a deduction and shouldn't have any basic stable evaluation, *Logistic* equation still can provide abstractive expression for structuring in a smooth phase. Enterprise knowledge system is a kind of economic system, contains all those features of economic system evolution in its self-organization. In order to describe the process for enterprise knowledge system from an equilibrium state to a new one, as well as the fluctuation or emergence characteristics beside the tipping point, we adopt *Logistic* equation in this paper to identify regularity of knowledge collaboration.

Considered of the normal form of *Logistic* equation, let X be structure variable, such as NSE of knowledge system, which will evolutions constantly over time:

$$\mathrm{X}_t = X_{t-1}[1 + b(1 - \frac{X_{t-1}}{K})] + u_t \tag{5}$$

In which b is diffusion ratio or structure ratio, and K is load capabilities and u_t is deviation. The change of structure ratio in a unit of time from Equation (5) should be:

$$\frac{\mathrm{X}_t - \mathrm{X}_{t-1}}{X_{t-1}} = b - b\frac{X_{t-1}}{K} + \frac{u_t}{X_{t-1}}$$ or approximately : $$\ln X_t - \ln X_{t-1} = b - b\frac{X_{t-1}}{K} + e_t \tag{6}$$

In which, $e_t = \frac{u_t}{X_{t-1}}$。Equation（6）can be further extended as：

$$\ln X_t - \ln X_{t-1} = [b(...)][1 - \frac{X_{t-1}}{K(...)}] + e_t \quad (7)$$

In which *b* and *K* also become functions of other variables. Function *b(…)* contains various factors affected on diffusion ratio and is no longer a constant over time. Function *K(…)* then consider various factors which can extend or contract the load capability of knowledge system. Generally, factors contained in Function *b(…)* have short influence on economic system and factors in Function *K(…)* have long influence which is deterministic on structuring.

The possibility of unstable and discontinuous structure transform of Knowledge system while it get into the structuring stage of *Logistic* curve. It is helpful for economic self-organization analysis to endogenous the basic parameters of logistic equation.

4.2.2. Government means of Logistic Equation: There are two important problems should be considered while researching on collaboration evolution of enterprise knowledge system, one is what factors will affect the diffusion ratio or structuring ratio, and another one is what factors will affect the tipping point of structuring. Which factor can be contained into function *b(…)* and *K(…)* should be determined by the existence of knowledge evaluation, exchange and contract.

According to economic theory, short term factors mainly are economic and measurable, such as relative price and flow of knowledge contained in function *b(…)*, and long term factors mainly are uneconomic and not to be measured, such as variable in layer of system, culture and mentality of enterprise knowledge system contained in function *K(…)*. Short term factors will affect the diffusion ratio of system in the near future, but the movement of unmeasurable variables like the change of governance structure or supervision system, will have deterministic effect on structuring process in long time. Through research on system, those important changes and its happen time should be identified and should be expressed as different qualitative movement variable.

Equation (7) provides a possibility to quantitative observe the evolution process of enterprise knowledge system. Through data calculating, the logistic relationship can be confirmed so that basic logistic form can be separated from it and which structuring stage the knowledge system stayed in also can be identified. Based on these determinations, the stability of knowledge system structure can be assessment while outside impact happened such as knowledge lash resulted from dramatic change of competitive environment. When knowledge system developed into the saturation stage of logistic curve, its structure will face the challenges of unstable or structure interrupt. It is helpful to study on these features of this stage for enterprise to execute necessary measures to avoid key knowledge oscillation caused by structure interrupt and adjust policies guiding knowledge system evenly transmit to new stage.

5. Conclusion

It is not so effective for traditional knowledge management to manage tacit knowledge (Yan *et al.*, 2001). But E2.0 has taken new opportunity for knowledge

collaboration because of its more powerful capability to solve practice problems with tacit knowledge. In this paper, we constructed the self-organization concept model and logistic process analysis model of knowledge system in E2.0 environment, which are to explore the evolution pattern of knowledge collaboration system in favor of the organization mechanism design for enterprise knowledge governance. In future, there are some topics should be discussed, including the simulation calculation of knowledge system evolution in E2.0 environment, searching for the upper limit, lower limit and optimal value, presumption appropriate control parameters and formulation of governance structure and strategies.

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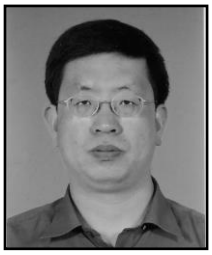

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