Journal of the Korea Industrial Information Systems Research Vol. 19 No. 6, Dec. 2014
http://dx.doi.org/10.9723/jksiis.2014.19.6.097

사회연결망을 이용한 지식전파 분석의 프레임워크†

(A Framework for Knowledge Propagation Analysis using Social Network)

황 현 석[1)]
(Hyun-Seok Hwang)

요 약 기업은 조직내에서 공유되고 사용되는 지식을 경쟁우위와 직결된 지적자본으로 인식하고 있다. 이에 따라 많은 선행연구에서 지식근로자 사이에 공유되는 지식을 파악하고자 노력하였다. 선행 연구의 한 가지 접근법은 정보기술을 이용하여 자동화되고 효율적으로 명시적인 지식을 공유하는 기술적인 방법을 강조하는 접근법이며 다른 접근법은 지식근로자간 휴먼 네트워크를 이용하여 암묵적인 지식의 흐름을 파악하고자 하는 연구이다. 두 번째 접근법의 경우 지식공유를 위해 실행공동체의 역할이 강조되고 있으나 자발적인 참여가 아닌 경우 실행공동체를 파악하기 힘들다는 단점이 있다. 본 연구에서는 휴먼 네트워크를 사회연결망 관점에서 파악하여 지식의 전파를 분석하고 실행공동체에 참여할 수 있는 지식근로자를 찾아내는 방법을 제안하고자 한다. 이를 위해 두 가지 사회연결망 관련 지표를 이용하여 지식 근로자를 분류하는 프레임워크를 제시하고 실무적용 가능성을 확인한 결과를 제시하고자 한다.

핵심주제어 : 지식전파분석, 지식네트워크, 사회연결망, 지식공유

Abstract A company regards knowledge shared and used within a corporate organization as intellectual capital linked to corporate competences. A great deal of research has been conducted in the past to identify knowledge sharing among knowledge workers. Some papers focus on information technology for automated, efficient, and explicit knowledge sharing. Other papers emphasize the role of social networks to identify the flow of tacit knowledge. Though the role of CoP(Community of Practice) is emphasized to facilitate knowledge management among workers, it is not an easy task to identify the potential members of CoP without voluntary participation of the workers. In this study we adopt a social network approach to analyze knowledge propagation and to identify the potential members of CoP. We suggest a framework for classifying knowledge workers and the result of feasibility study.

Key Words : Knowledge propagation analysis, Knowledge network, Social network, Knowledge sharing

1. Introduction

Recently, most companies regard knowledge in an organization as one of the important resources of acquiring competitive edge. A company's employees are encouraged to propagate and share their

† 본 연구는 한림대학교 학술연구비 지원(HRF-201311-006)에 의해 연구되었음.
1) 한림대학교 경영학부, 한림경영연구소, 제1저자

knowledge with co-workers. Knowledge Management pertains to managerial efforts to maximize organizational competence by extracting, disseminating, sharing, and reusing valuable human knowledge in an organization.

However, knowledge propagation or sharing is difficult to ensure, because core knowledge is created and stored within the human brain and disseminated through social networks. Therefore, it is very important to be aware of knowledge propagation mechanism which facilitates tacit knowledge sharing in an organization.

Since the most practical way of sharing tacit knowledge within an organization is communication among workers, it is essential to identify social networks and the amount of shared knowledge propagated within the networks.

In this paper, we aim to suggest a framework for knowledge propagation analysis using social networks and suggest the way of identifying the potential CoPs within an organization. Firstly, we review the previous works regarding social networks as instruments of communication and a means of knowledge sharing among employees. We propose a framework for knowledge propagation analysis using social network analysis. The suggested framework includes the six categories of knowledge workers classified with metrics of social network analysis coupled with the method of identifying some key players in social networks - so called Community of Practice (CoP) - a group people who activate intellectual capital, foster knowledge sharing, disseminate and evaluate tacit knowledge within an organization.

To verify our framework, we utilized a questionnaire and the survey results are analyzed using the suggested framework with managerial implications.

2. Related Works

In order to analyze knowledge propagation mechanism in an organization, we reviewed the previous social network research of social network, concentrating on Knowledge Management, There are two approaches of enhancing knowledge dissemination: i) a technological approach emphasizing the use of information technology and the automation of knowledge mining, knowledge retrieval, and knowledge deployment [1-3]. ii) a non-technological approach focusing on manual propagation of tacit knowledge among network participants through human interactions.

2.1 Social Network

A social network is a set of people, organizations or other social entities connected by relationships, including, but not limited to, friendship, employment or information exchange [4]. Social networks play important roles in our daily lives. People conduct communications and share information through social relations with others such as friends, family, colleagues, collaborators, and business partners [5]. Social networks are explicit representations of the relationships between individuals and groups in a community [6]. Social Network Service (SNS) enables web users to build their private social networks on the web. MySpace and Facebook, typical SNS companies, encourage new ways of communicating and sharing information.

Social Network Analysis (SNA) is an approach to analyzing organizations focusing on the relationships between people and/or groups as the most important aspect [7]. The basic components of an SNA study are the actors or nodes, as the sources of action, and the connections or links, as the relationships developed among nodes [8]. The most important goal of SNA is to make recommendations to improve communication and workflow in an organization [9].

2.2 Social Network in KM

Knowledge management is a managerial effort to gain an organizational competence – organizational capabilities, efficiencies and competitive advantages – through facilitating the better use of individual and collective knowledge in an organization.

Knowledge sharing among people in an organization is a crucial factor in fostering knowledge management. Knowledge sharing requires collaboration between the consumers and contributors of knowledge; namely the collaborators [10]. Social networks are developed based on the idea that a determinable networking structure of how people interrelate exists. In such networks, people connected – either directly or indirectly – through common social relationships [11].

According to the research results of Cross et al. (2001), company managers overwhelmingly indicated that they receive information critical to the project's success from personal networks far more frequently than impersonal sources such as their personal computer archives, the Internet or the organization's knowledge management databases. Understanding how knowledge flows across these various boundaries within an organization can yield critical insight into where management should target efforts to promote collaboration [12].

The study of Chow & Chan (2008) showed that (i) a social network significantly contributed to attitudes toward knowledge sharing; (ii) a social network significantly contributed to the subjective norm on knowledge sharing; and (iii) a social network had indirect effects on the intention to share knowledge within the organization [13].

Norman & Huerta (2006) studied knowledge transfer and exchange through social networks and found that the shape and size of a network can influence the collaboration and creation of CoP [14].

According to the research conducted by Wasko et al.(2005), people tends to contribute their knowledge when they are structurally embedded in the networks. The researchers also found that people contribute their knowledge with no expectations of reciprocity from others [15].

As shown in the previous research, analyzing social networks among knowledge workers provides an effective and efficient way of identifying knowledge propagation and knowledge sharing within an organization.

2.3 Community of Practice

CoP is a collective, collaborative and interactive network of knowledge workers. CoP arose as a voluntary, autonomous and leading community of knowledge management [16].

Lesser and Storck (2001) found that organizational outcomes could be impacted by the activities of CoP [17]. Organizational outcomes include:

- Reducing the learning curve of new employees;
- Enhancing quick response to customer needs and inquiries;
- Decreasing redundant works; and
- Generating new ideas for products and services.

The research conducted by Ardichvili et al. (2003) aimed to discover the motivation and hurdle of contribution to virtual communities of practice [18]. They found that the majority of knowledge workers regard their knowledge as belonging to their organization and not to them personally. Knowledge sharing is motivated by moral obligation and organizational interest, not by a self-interest.

Nonaka and Toyama (2003) revisited the theory of knowledge creation [19]. They tried to advance their SECI process (knowledge sharing process) and Ba by further using the dialectic thinking. They emphasized the role of network as a knowledge-creating place and insisted that various contradictions are synthesized through interactions among individuals, the organization dynamically.

Some researchers suggested the existence of "Hidden or Potential CoPs".

Ribeiro & Kimble (2008) addressed that

identifying the "hidden CoPs" is required if CoPs are either unknown or not established yet [20].

Wenger (1998) divided communities in two separate states: potential communities and latent communities [21]. Another study conducted by Cappe (2008) examined latent CoPs - seeds CoPs - in an organization [22].

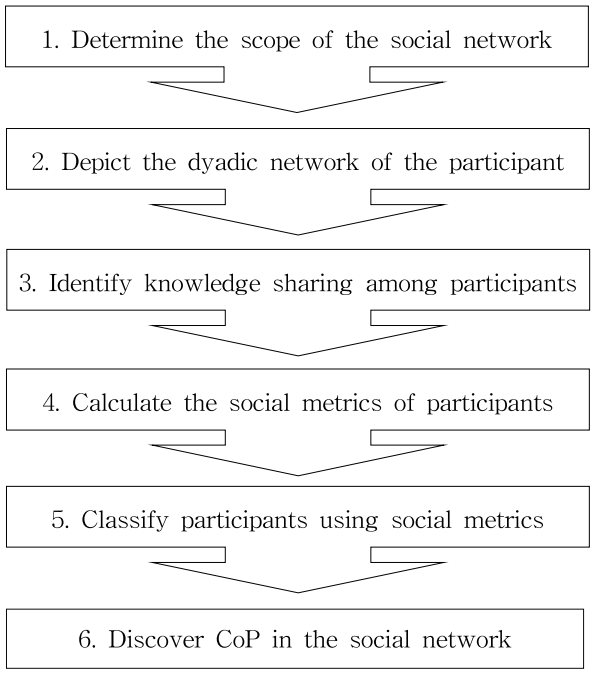
These research studies examined the existence of hidden or latent CoPs; however, no framework to reveal the hidden CoPs is suggested. Therefore, it is necessary to identify the potential CoPs when knowledge management is in its early stages and CoPs are not established.

3. Research Framework

To identify potential CoPs in premature stage of Knowledge Management, we need a framework to analyze the status of knowledge sharing and to find candidate members of CoPs.

Wenger and Snyder (2000) addressed that CoPs can add value to organizations by sharing and spreading their best practices across a company. They also recommended that the managers should identify the potential CoPs to enhance the company's strategic capabilities. Hence, we use the current status knowledge sharing activities of an individual worker through Social Network Analysis to identify the potential CoPs. The fundamental idea of finding potential CoPs in this study is that the more a worker is active in disseminating her/his knowledge to others, then the more likely the potential is that s/he can be a member of the CoPs. The second idea is that the more a worker mediates the knowledge transfer among other workers, then the more likely the potential is that s/he can be a member of the CoPs. If a worker is located in the path of disseminating knowledge within an organization, s/he stands at a vantage point for transferring knowledge.

We suggest the following framework to identify knowledge sharing through social networks.



<Fig. 1> Research Framework

Firstly, we determined the scope of social network. The scope can be all company employees or the members of a team. In case of choosing all company employees, we can identify all aspects of knowledge sharing among workers. However it will be a very time-consuming task to gather and analyze the data.

The next step is depicting the binary relation between two participants. Each participant depicts an ego-centric network. We can identify the whole network by combining all individual ego-centric networks.

The third step is identifying knowledge sharing among participants based on the network depicted in the previous step. The aspects of knowledge sharing can be described as the amounts of sharing with other participants or possibilities of sharing with other participants. As a result of step three we can build a propagation matrix whose components are the values or the amounts of sharing among participants.

The fourth step is calculating the social metrics of each participant. In this step we identify three metrics: i) inflow, ii) outflow, iii) betweenness centrality. The first two metrics are used to compute the ratio of donating and receiving knowledge. Inflow is the total amount of receiving knowledge from other participants. Outflow is the sum of all outbound knowledge devised to measure contribution of donating knowledge to other participants. The third metric is devised to measure mediating role of a participant.

The fifth step is classifying the participants involved in the process of knowledge propagation and sharing based on the knowledge relative flow intensity (outflow divided by inflow), and betweenness centrality.

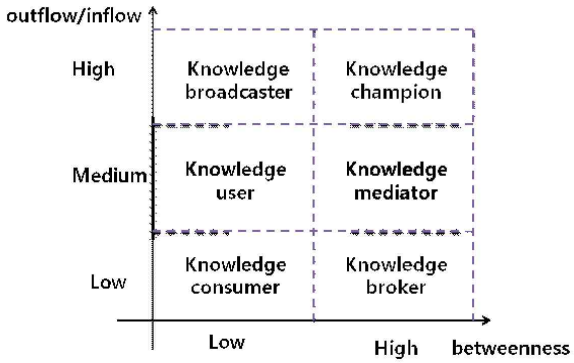
The final step is analyzing each participant's role in a social network related to Knowledge Management and discovering CoP – the core members of facilitating Knowledge Management.

We classify social network participants into six categories considering the social metrics as shown in <Fig. 2>.

Betweenness denotes betweenness centrality of each participant measuring a degree of mediating participant's knowledge. In general, a large number of participants have low betweenness value. Each role can be described as follows:

i) The knowledge champion is the most vigorous participant in a knowledge propagation matrix. S/he disseminates/donates knowledge rather than receives knowledge, and much knowledge is passed through her/him. Usually s/he may be a critical role in sharing, disseminating knowledge within a social network.

ii) The knowledge mediator has a wide acquaintance within an organization. Many participants share knowledge with her/him. Most shared knowledge is passed through her/him.



<Fig. 2> Participant classification

iii) The knowledge broker has limited acquaintance when compared with the knowledge mediators. Generally the knowledge brokers have several knowledge sharing groups and share their knowledge with a limited number of participants. S/he may be called the knowledge broker

iv) The knowledge broadcaster (also called the knowledge evangelist) plays a key role to disseminate her/his inflow knowledge to others for knowledge propagation. The ratio, outflow/inflow, is higher than the other five types of participants. However, betweenness centrality of the knowledge broadcaster is lower than that of the knowledge champion.

v) The knowledge user is the most common type of participants. S/he uses the knowledge received from colleagues and distributes that knowledge further to other colleagues.

vi) The knowledge consumer (also called knowledge absorber) mainly receives knowledge from other workers without sharing the knowledge with others. S/he acts as a sink node in a network.

4. Feasibility study

To validate the feasibility of the suggested framework, we chose a team having eight members

and asked them questions regarding the amounts of knowledge sharing with co-workers. The dyadic network can be summarized as the following propagation matrix **P** in <Fig. 3>.

Let a_{ij} be the element of i^{th} row, j^{th} column denoting the amount of knowledge transmitted by i^{th} participant to j^{th} participant in a square matrix **P**. **P** is not symmetric since the amount of knowledge transmitted by i^{th} participant to j^{th} participant may be unequal to the amount of knowledge transmitted by j^{th} participant to i^{th} participant. a_{ij} has a value between 0 and 1. If a_{ij} equals to 1, participant i shares all the tacit knowledge that s/he possess with participant j. However a_{ij} equals to 0, participant i share no knowledge with participant j. Therefore the values of all diagonal elements, a_{ii}, are 1.

P =

	A	B	C	D	E	F	G	H
A	1	0.6	0.5	0.8	0.4	0.7	0.6	0.5
B	1	1	0.8	0	0	0	0	0
C	0.5	0.5	1	0.8	0.1	0.1	0.1	0.1
D	0	0	0.1	1	0.1	0.1	0.1	0.1
E	0.9	0.5	0.2	0.8	1	0	0	0
F	0	0	0	1	0	1	0.5	1
G	0	0	0	0.2	0	0	1	0
H	0	0	0	1	0	1	1	1

<Fig. 3> Propagation matrix

The dydadic network typology can be represented graphically as shown in <Fig. 4>.

The value on the each arrow means the element in propagation matrix **P**. The element valued 0 is not linked in <Fig. 4> since the corresponding participants do not share their knowledge at all.

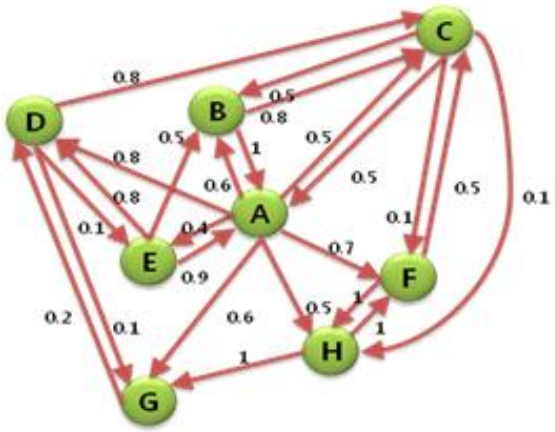
All possible combinations of two participants, the shortest path and the amount of knowledge transmission are listed in <Table 1>.

Another measure of classification is betweenness centrality. Betweenness centrality of participant i, $B(i)$, can be calculated by the following equation:

$$i) = \sum_{\neq v_j \neq v_k, i<j} \frac{N_{ij}(k)}{N_{ij}} \Big/ (n-1)(n-2)/2 \quad (1)$$

V denotes set of all nodes (participants) in a social network. n denotes the number of total nodes. N_{ij} denotes the amount of transmitted knowledge through the shortest path between all possible two source node i and target node j. $N_{ij}(k)$ denotes the amount of transmitted knowledge through the shortest path between all possible two source node i and target node j via node k.

When we calculate the betweenness centrality of nodes, the number of possible combination of matching two participants is $(n-1)(n-2)/2$. The divisor, $(n-1)(n-2)/2$, is used to normalize the betweenness centrality index to compare different networks.



<Fig. 4> Graphical representation of Propagation matrix

Using the base table, two important measures, the ratio of outflow and inflow, and betweenness centrality as calculated and summarized in <Table 2>.

To divide three level of outflow/inflow(low/medium/high), we use standard deviation of outflow/inflow and $1 \pm 0.5\sigma$ is used for classification criterion. If we assume that the average ratio of outflow/inflow is 1, then $1 \pm 0.5\sigma$ range includes

<Table 1> Base table for betweenness centrality

i	j	shortest path (i→j)	shortest path (j→i)	Knowledge Transfer (i→j)	Knowledge Transfer (j→i)
A	B	AB	BA	0.6	1
A	C	AC	CA	0.5	0.5
A	D	AD	DCA	0.8	0.4
A	E	AE	EA	0.4	0.9
A	F	AF	FCA	0.7	0.25
A	G	AG	GDCA	0.6	0.08
A	H	AH	HFCA	0.5	0.25
B	C	BC	CB	0.8	0.5
B	D	BAED	DCB	0.32	0.4
B	E	BAE	EAB	0.4	0.54
B	F	BAF	FCB	0.7	0.25
B	G	BAG	GDCB	0.6	0.08
B	H	BAH	HFCB	0.5	0.25
C	D	CAD	DC	0.4	0.8
C	E	CAE	EAC	0.2	0.45
C	F	CAF	FC	0.35	0.5
C	G	CAG	GDC	0.3	0.16
C	H	CAFH	HFC	0.35	0.5
D	E	DCBAE	ED	0.16	0.8
D	F	DCF	FHGD, FCAD	0.4	0.2
D	G	DG	GD	0.1	0.2
D	H	DCH	HFCD	0.08	0.4
E	F	EAF	FCAE	0.63	0.1
E	G	EAG	GDCAE	0.54	0.032
E	H	EAFH	HFCAE	0.63	0.1
F	G	FHG	GDCF	1	0.016
F	H	FH	HF	1	1
G	H	CDCH	HG	0.016	1

<Table 2> classification measure

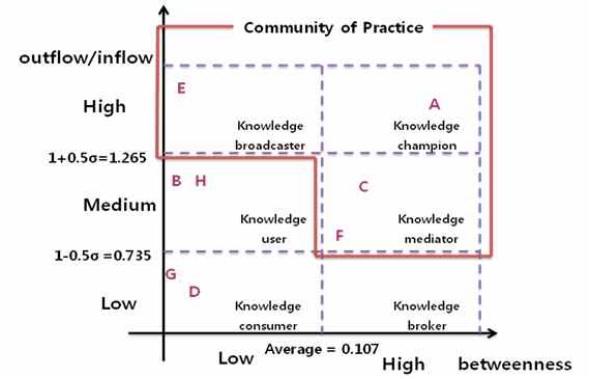
worker	outflow/inflow	betweenness
A	1.50	0.44
B	1.08	0.01
C	1.03	0.18
D	0.36	0.04
E	2.13	0.02
F	0.89	0.11
G	0.44	0.00
H	1.15	0.06

about 38.3% of participants. In case of betweenness centrality, the average value is used for classification.

<Fig. 5> shows the classification result of eight participants. Since the standard deviation of outflow/inflow is 0.265, the medium range of outflow/inflow is between 1.265 and 0.765 and includes 4 participants.

In this study we regard a member of CoP as having the following characteristics: i) donating her/his knowledge to other participants rather receiving knowledge from other participants. ii) mediating other participants' knowledge and disseminating the knowledge. In this study we regard the participants with high outflow/inflow

ratio or high betweenness metrics as the members of CoP. Therefore the knowledge broker, knowledge mediator, and knowledge champion are the typical categories of CoP.



<Fig. 5> Classification Result of Participants

After finding theses key players, a company needs to request participants **A**, **C**, **E**, **F** to join CoP and to lead the entire company-wide knowledge sharing activities - knowledge extraction, evaluation, dissemination, and propagation.

5. Conclusion

Understanding how knowledge is propagated across various boundaries within an organization can provide critical insight for knowledge management.

In this study, we suggest a framework for classifying knowledge worker using two measures, outflow/inflow ratio and betweenness centrality. The result of classification is consistent with topology shown in <Fig. 5>. Participant **A** plays a key role in sharing knowledge. Many connections are linked and communication between some participants should pass through Participant **A**.

The suggested framework can be used several ways. CoP(Community of Practice), the core player of knowledge management, can be identified. Since participants **A**, **C**, **E**, **F** are active players of knowledge dissemination or knowledge brokerage among workers, they can form CoP as shown in <Fig. 4>.

This study, however, has some limitations: a) If there are a large number of participants, the procedure of calculating betweenness centrality will be very complicated work. b) We only focused on knowledge propagation but knowledge creation, an important candidate for classification criterion, is not considered.

In the future, this study will extend to consider another measure for classifying knowledge workers and their knowledge activities such as knowledge creation, dissemination, consumption, transformation and so on.

References

[1] Y. Cha, and S. Yoo, “A study on the direction of knowledge management implementation for retail firms”, Journal of Korean Industrial Information Systems Society, Vol. 7, No. 5, pp. 129-146, 2002.

[2] Y. Joo, "Intelligent System Design for Knowledge Representation and Interpretation of Human Cognition", Journal of Korean Industrial Information Systems Society, Vol. 16, No. 3, pp. 11 - 21, 2011.

[3] H. Kim, J. Cho, "A design of efficient emergency medical information system using heuristic knowledge", Journal of Korean Industrial Information Systems Society, Vol. 18, No. 3, pp. 47-56, 2013.

[4] L. Garton, C. Haythornthwaite, and B. Wellman, "Studying Online Social Networks", Journal of Computer-Mediated Communication, Vol. 3, No. 1, 1997.

[5] Y. Matsuo, J. Mori, M. Hamasaki, T. Nishimura, H. Takeda, K. Hasida, and M. Ishizuka, "POLYPHONET: An advanced social network extraction system from the Web", Web

Semantics: Science, Services and Agents on the World Wide Web, Vol. 5, No. 4, pp. 262-278, 2007.

[6] T. Finin, D. Li, Z. Lina, and J. Anupam, "Social networking on the semantic web", The Learning Organization, Vol. 12, No. 5, pp. 418-435, 2005.

[7] S. Wasserman, and F. Katherine, "Social Network Analysis: Methods and Applications", Cambridge University Press, 1994.

[8] J. Wang, and C. Chiu, "Recommending trusted online auction sellers using social network analysis", Expert Systems with Applications, Vol. 34, No. 3, pp. 1666-1679, 2008.

[9] A. H. Dekker, "A Category-Theoretic Approach to Social Network Analysis", Electronic Notes in Theoretical Computer Science, Vol. 61, pp. 21-33, 2002.

[10] S. J. H. Yang, and I. Y. L. Chen, "A social network-based system for supporting interactive collaboration in knowledge sharing over peer-to-peer network", International Journal of Human-Computer Studies, Vol. 66, No. 1, pp. 36-50, 2008.

[11] E. F. Churchill, and C. A. Halverson, "Social networks and social networking", IEEE Intelligent Systems, Vol. 20, No. 5, pp. 14-19, 2005.

[12] R. Cross, A. Parker, L. Prusak, and S. P. Borgatti, "Knowing What We Know: Supporting Knowledge Creation and Sharing in Social Networks", Organizational Dynamics, Vol. 30, No. 2, pp. 100-120, 2001.

[13] Wing S. Chow, and L. S. Chan, "Social network, social trust and shared goals in organizational knowledge sharing", Information & Management, Vol. 45, No. 7, pp. 458-465, 2008.

[14] C. D. Norman and T. Huerta, "Knowledge transfer & exchange through social networks: building foundations for a community of practice within tobacco control", Implementation Science, Vol. 1, pp. 1-11, 2006.

[15] M. M. Wasko and S. Faraj, "Why Should I Share? Examining Social Capital and Knowledge Contribution in Electronic Networks of Practice", MIS Quarterly, Vol. 29, No. 1, pp. 35-57, 2005.

[16] E. C. Wenger, and W. M. Snyder. "Communities of Practice: The New Organisational Frontier", Harvard Business Review, Vol. 78, No. 1, pp. 139-145, 2000.

[17] E. L. Lesser, and J. Storck, "Communities of practice and organizational performance", IBM Systems Journal, Vol. 40, No. 4, pp. 831-841, 2001.

[18] A. Ardichvili, V. Page, and T. Wentling, "Motivation and barriers to participation in virtual knowledge sharing communities of practice", Journal of Knowledge Management, Vol. 7, No. 1, pp. 64-77, 2003.

[19] I. Nonaka, and R. Toyama, "The knowledge-creating theory revisited: knowledge creation as a synthesizing process", Knowledge Management Research & Practice, Vol. 1, No. 1, pp. 2-10, 2003.

[20] R. Ribeiro, C. Kimble, "Identifying 'Hidden' Communities of Practice within Electronic Networks: Some Preliminary Premises", Proceedings of 13th UKAIS Conference, 2008.

[21] Wenger, E., Communities of Practice: Learning, Meaning, and Identity, New York, Cambridge University Press, 1998.

[22] E. Cappe, Conditions d'émergence et de développement des communautés de pratique pour le management des connaissances, Ph.D doctoral dissertation, Universite Pierre Mendes, Grenoble, France, 2008.

황 현 석 (Hyun-Seok Hwang)

- 정회원
- POSTECH 산업경영공학과 공학사
- POSTECH 산업경영공학과 공학석사
- POSTECH 산업경영공학과 공학박사
- 한림대학교 경영대학 경영학부 교수
- 관심분야 : 지식경영, 빅데이터, 비즈니스 인텔리전스, 데이터 마이닝

논 문 접 수 일 : 2014년 10월 23일
1차수정완료일 : 2014년 12월 03일
게 재 확 정 일 : 2014년 12월 08일