行政院國家科學委員會補助專題研究計畫

☑成果報告 □期中進度報告

建構互動記憶網路促進虛擬組織學習

計畫類別：☑ 個別型計畫 □ 整合型計畫
計畫編號：NSC 96-2416-H-029-007-
執行期間： 96 年 08 月 01 日至 97 年 07 月 31 日

計畫主持人：林盛程
共同主持人：無
計畫參與人員： 吳家銓、李致豪、陳卉芳

成果報告類型(依經費核定清單規定繳交)：☑精簡報告 □完整報告

本成果報告包括以下應繳交之附件：
□赴國外出差或研習心得報告一份
□赴大陸地區出差或研習心得報告一份
☑出席國際學術會議心得報告及發表之論文各一份
□國際合作研究計畫國外研究報告書一份

處理方式：除產學合作研究計畫、提升產業技術及人才培育研究計畫、列管計畫及下列情形者外，得立即公開查詢
□涉及專利或其他智慧財產權，□一年□二年後可公開查詢

執行單位：東海大學

中文摘要

隨著網路通訊技術的發達，虛擬組織日漸蓬勃發展，而虛擬組織跨組織合作的特性無形中提供了組織成員間相互學習的機會。目前著眼於有關如何幫助虛擬組織成員進行組織學習的研究卻仍屬有限。因此，本研究首先從互動記憶(Transactive Memory)的觀點出發，建構了由知識地圖(Knowledge Map)、人際網路(Social Network)、以及記憶操作功能(Mnemonic Functions)等組成以互動記憶為中心的虛擬組織學習概念模式。接著，為了進一步將此模式加以實作，在本研究我提出互動網路(Transactive Networks)的多重代理人(Multiagent)系統架構。此架構中包含五個主要的軟體代理人：知識需求配對管理者(Matchmaking Manager)、技能管理者(Skills-based Manager)、貢獻管理者(Contribution Manager)、互動環境管理者(Context Manager)、以及人際網路管理者(Social Network Manager)。希望藉由詳細描寫其各自負責的功能及彼此間的互動，來了解這些元件如何幫助知識需求者找到合適的知識貢獻者、如何增進成員學習的意願、如何鼓勵成員分享個人記憶、如何協助對談順利進行、如何有助於人際網路的延展，並進而促進虛擬組織學習。本研究運用知識管理相關理論與技術來探索促進虛擬組織學習的可行性。

關鍵字：多重代理人、互動記憶、虛擬組織、組織學習

Abstract

More and more virtual organizations are emerging due to the progressive information and telecommunication technologies. A virtual organization is a temporary network of companies, which implies the potential opportunity to learn and share abundant sources of complementary and compatible knowledge possessed by members. Learning in a virtual organization is the key to achieve agility of a virtual organization; however, few studies are focused on this dimension. Therefore, I attempt to bring insights of learning in a virtual organization by developing a framework of transactive networks system including five software components as matchmaking manager, skills-based manager, contribution manager, context manager, and social network manager. With the proposed multiagent-based system, I illustrated how it can be of help to connect both knowledge requesters and appropriate knowledge contributors to augment and retain the social networks in fostering virtual organizational learning. In addition, I hope it will also contribute to increase the flux of dialogue through instill the desire to learn, inspire the willingness to broaden accessible individual memory, and smoothen the communication processes. The contributions of this research can be viewed in two dimensions: knowledge management technologies, and knowledge sharing and learning in virtual organizations.

Keywords: Transactive memory, Virtual organization, Organizational learning

本研究研究結果已發表於

Sheng-cheng Lin, Yu-Min Wang, Daniel Y. Shee, A Conceptual Framework of Transactive Networks System, In *Proceedings of the 41th Annual Hawaii International Conference on System Sciences (HICSS2008)*, January 7-10, Hawaii, 2008. (EI)

A Conceptual Framework of Transactive Networks System

Sheng-cheng Lin
Department of Information Management
Tunghai University
sclin@thu.edu.tw

Yu-Min Wang
Department of Information Management
National Chi Nan University
ymwang@ncnu.edu.tw

Daniel Y. Shee
Department of Information Management
National Changhua University of Education
dyshee@cc.ncue.edu.tw

Abstract

A virtual organization is a temporary network of companies, which implies the potential opportunity to learn and share abundant sources of complementary and compatible knowledge possessed by members. Learning in a virtual organization is the key to achieve agility of a virtual organization; however, few studies are focused on this dimension. Therefore, this research attempts to bring insights of learning in a virtual organization by developing a framework of transactive networks system including five software components as matchmaking manager, skills-based manager, contribution manager, context manager, and social network manager. With the proposed multiagent-based system, this study illustrates how it can be of help to connect both knowledge requesters and appropriate knowledge contributors to augment and retain the social networks in fostering virtual organizational learning. The contributions of this research can be viewed in two dimensions: knowledge management technologies, and knowledge sharing and learning in virtual organizations.

1. Introduction

Virtual organizations are assuming an increasingly prominent role against the background of today's dynamic environment. With more and more business processes intertwined across organizational boundaries and more specialized division of labor, no one person can possess all the knowledge necessary to complete a task; furthermore, what constitutes "necessary" knowledge is continually changing. For example, a programmer may find himself always get into scrapes due to the continuously evolving coding techniques or possessing of partial knowledge and virtually no control over the behavior of the components created by other designers in open environments [22]. In a virtual organization, members may possess both complementary and compatible knowledge, and thus such form of organizational structure can be a treasure-house and shed lights on the need to learn and share knowledge throughout the organizations involved. Some researchers promote learning by introducing "vision" and "values" into the daily lexicon and practice, but are criticized to be too idyllic to realize [15].

More and more studies focus on the employment of technologies to facilitate organizational learning and knowledge sharing (e.g., [1, 2, 16, 45]). Most of these researches emphasize on the needs of the knowledge requester, but ignore the context of the knowledge contributor. For instance, if people are ardent to share what he or she knows, they may have no idea who needs their help anxiously, whether the requester is trustworthy of sharing knowledge, and which level of expertise the requester appreciates to avoid the reception gap between provider and requester. In addition, although culture has been identified the principal factor to promote organizational learning and knowledge sharing (e.g., [3, 10]), many studies emphasize the compensation strategies rather than the enabling technologies to foster such a culture. Furthermore, for a knowledge requester, he or she may wish to obtain knowledge needed as soon as possible, but the physical and emotional availability of the appropriate responders is also questionable.

Steil et al. [44] formulate several strategies to overcome the potential barriers for learning in virtual organizations and conclude that the conversion of tacit knowledge to explicit knowledge is harder to accomplish than the conversion of tacit knowledge in one person to new tacit knowledge in another person or group, and thus specially stress the importance of the socialization knowledge conversion process identified by Nonaka [33]. Further, many studies

also point out the socialization, face-to-face communications or dialogues are powerful vehicles to knowledge transfer or learning (e.g., [21, 23, 28, 39]). Therefore, traditional codification strategies remain un-applicable here, even the personalization may be out at the elbows to deal with one-shot conversation and capture it to augment the organizational memory [17]. All questions proposed in light of the need to establish certain mechanisms that reinforce active learning and encourage knowledge sharing in virtual organizations. Therefore, this research proposed a framework of transactive networks and managed to implement the model through the multiagent technology.

2. Literature Reviews

2.1 Organizational Learning in Virtual Organizations

An organization is composed of individuals, and an organization ultimately learns via its individual members [26]. In an organization's infancy organizational learning can be considered as synonymous with individual learning. Few organizations would doubt the importance of individual learning to their own survival and competitive advantage [3]. Duncan and Weiss [14] argue that an individual is the only entity in the organization who can learn, individuals must be viewed as part of a learning system for exchanging what is learned among individuals. The process of knowledge exchange is of a social nature, or in their terms, an extra-individual process, which takes place in social interaction.

Dixon views organizational members as having meaning structures that could be categorized as *private, accessible* and *collective*. The private meaning structure is composed of those parts of organizational members' cognitive maps, which they choose to withhold from other members. The accessible meaning structure is built by an individual's cognitive map, which he or she is willing to make available to others. The collective meaning structure is the cognitive maps, which organizational members hold jointly with other members. For organizational learning to occur, Dixon [11] points out it is not enough by simply encouraging organizational members to exchange their accessible meaning structures with each other; the organization must actively facilitate collective learning. Organizational learning requires individual learning, and individual learning has to interact in a dynamic social environment in order to contribute organizational learning [40].

A virtual organization can be defined as a temporary network of companies that comes together quickly to exploit fast-changing opportunities [6]. The most significant characteristic of virtual organizations is the involvement of several organizations, and which implies the potential opportunity for organizational members to learn and share the abundant sources of diverse knowledge. According to Zucker [55], bureaucracies often lack "expert" information and must therefore seek it externally. An external "information network" of experts can provide the firm with multiple evaluations of the value of its own information and know-how, thereby increasing its efficiency in searching for valuable information, screening information, and codifying information for managerial use.

Furthermore, Liebeskind et al. [31] identify that the use of boundary-spanning social networks by the two biotechnology firms increases both their learning and their flexibility in ways that would not be possible within a self-contained hierarchical organization, and concluded organizations whose employees are members of a social network would learn more efficiently than organizations whose employees are not members of a social network. They also argue social network exchanges make two important contributions to organizational learning: extending the scope of organizational learning and integration of knowledge at firms. The contention is similar to Pedler et al.'s [35] work, who notes that a characteristic of a learning organization is that it extends its learning culture to include customers, suppliers and other significant stakeholders. In addition, due to the temporary collaboration feature of most virtual organizations and thus permit the swift trust to generate between members, it may offer the greater opportunities to augment the social networks.

The other significant difference of learning in virtual organizations is the geographical disperse of members, which mostly relies on information communication technologies. Steil et al. [44] designate several strategies for creating and disseminating tacit knowledge in virtual organizations and stress the importance to prompt ongoing discussions/questions. Ongoing discussions in digital format are also essential for helping the creation and dissemination of tacit knowledge. The greater the flux of communication among organizational members, the faster the rate of creation and dissemination of tacit knowledge

in virtual organizations. Schein [39] suggests that learning in groups takes place through conversation. Several studies also indicate mental models and tacit elements of expertise are always unconsciously or consciously externalized in one's communication style, especially in storytelling situations [5].

2.2 Transactive Memory

We may review the role of memory first. Argyris and Schon [4] argue that memory is necessary to organizational learning. The role of memory is interconnected with learning [8]. What we already have in our memory affects what we will learn and what we have learned contributes to our memory. Organizational memory is an instance of collective memory, which relies on knowledge that is spatially distributed throughout the processes, individuals, and artifacts of the organization and beyond its boundaries [45]. Organizational memory is vital for the organization's effectiveness and learning [14]. Walsh and Ungson [51] assert that organizational memory can be structured into six retention bins: *individuals, culture, transformations, structures, ecology,* and *external archives.* Hackbarth and Grover [16] further introduce a new bin, the *information bin*, to denote rich data stored in formal information systems.

There are five mnemonic functions, *acquisition*, *retention*, *maintenance*, *search*, and *retrieval*, to manipulate the organizational memory. Acquisition gathers the data, information, and knowledge from all available sources; retention is the locations that composes the structure of memory; memories must be maintained to make accessible by the way such as to decide how and when to update or delete files; the search function seeks more information, which updates, corrects, or adds to the organizational base; retrieval is the process which organizational memory can be called forth to support decision-making and problem solving [16, 45, 51].

Wegner [52] developed a concept of *transactive memory* for describing how people in close relationships share cognition, which means a shared system for encoding, storing, and retrieving information. For example, a husband may not know where to find candles around the house, but may still be able to find them in a blackout by asking his wife where the candles are. Each member can enjoy the benefits of the partner's memory by assuming responsibility for remembering just those items that fall clearly to him or her and then by attending the categories of knowledge encoded by the partner so that items within those categories can be retrieved from the partner when they are needed. Wegner [52] argues transactive memory systems have two major components: (1) the individual memories of the members and (2) the transactive processes that construct and use these individual memories in order to provide the group access to a larger pool of knowledge collectively. He later used the metaphor of a directory-sharing computer network to describe the three key processes of a transactive memory system [53].

(1) *Directory updating*: whereby people learn what others are likely to know,

(2) *Information allocation*: where new information is communicated to the person whose expertise will facilitate its storage,

(3) *Retrieval coordination*: which is a plan for retrieving needed information on any topic based on knowledge of the relative expertise of the individuals in the memory system.

The concept of transactive memory that links individual memories to form a larger knowledge pool and the notion of directory and retrieval coordination may help us to portray the learning systems and knowledge sharing networks in virtual organizations.

3. Transactive Networks System

With the continually changing "necessary" knowledge and the infeasibility to possess all the knowledge necessary to complete a task, especially the intertwined business processes across many organizations involved in a virtual organization, people will always be reminded with the needs to source requested knowledge from other's accessible memories. Attribute to the popular open systems and web-based technologies, information may flows up, down, around, and sideways easily, and people are no more isolated from information islands constrained by their working environments as in the past and capable of reaching others with ease. All they lack mostly is an enabling mechanism to bridge both knowledge requesters and appropriate knowledge contributors.

For organizational learning to occur, there are still more to do beyond the matchmaking function. Since individual learning has to interact in a dynamic social environment in order to contribute organizational learning, attempts to increase the flux of dialogue should be also highlighted. Each members in a virtual organization can be instilled the desire to learn, the willingness to broaden accessible individual memory, the possibility of

smoothening communication processes especially when they are talking to strangers, and therefore contributes to increase the flux of dialogue between them. Besides, due to the temporary operation feature of virtual organizations, links to members in seceded organizations should be retained to augment the social networks.

This study designates five software components as *matchmaking manager*, *skills-based manager*, *contribution manager*, *context manager*, and *social network manager* to facilitate these mechanisms accordingly as shown in Figure 1. They are actualized by the multiagent technology.

The agent metaphor can be thought as software objects that behave autonomously, have abilities to reason, and suitable to act in open environments. They can be designed to perform variously specific tasks, such as monitoring, notification. Besides, they can also have hierarchical relationships between them to have information accumulated upwardly. When agents interact and communicate with other agents, they formed the multiagent system or agent community [22, 50]. The interacting processes in multiagent systems mostly can be described as matchmaking processes. Consumer agents send requests to a matchmaking agent, and provider agents evaluate them. Provider agents advertise capabilities to matchmaking agents, and consumer agents compare those capabilities to their needs. Some researchers found it was easier to have consumer agents express their needs than to have provider agents summarize their capabilities [34].

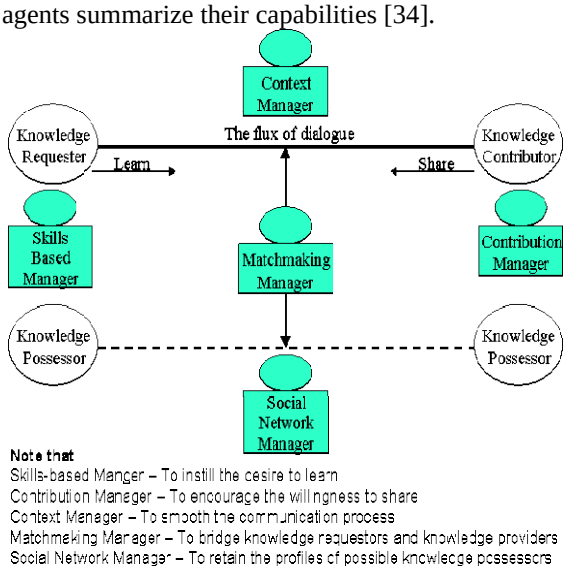


Figure 1. Five software components contribute to increase the flux of dialogue in a virtual organization

Characteristics such as the number of potential participants is large; communities have a dynamic nature; and individuality of each member is preserved are specific to network communities that make a multiagent architecture attractive to use [18]. All the enabling mechanisms can be seen as provided to afford transactive processes, and the linkages of accessible individual memories of members in virtual organizations can be termed as transactive networks.

3.1 Software Components in the Transactive Networks System

There are five major software components in the transactive networks model. Their roles and functions are described as follows.

3.1.1 Skills-based Manager. People may search for knowledge actively and passively. The former occurs when they encounter problems in performing certain tasks and thus requests knowledge from outside passively. The latter takes place when they recognize the needs to self-learning to fill a position capably. To encourage the flux of dialogue in demand side, I argue there ought to be some mechanisms existed to infuse the needs for people to learn by identifying their skill gaps, and designate the skills-based manager based on the concept of skills-based management. Skills-based management proposed by Riehl [37] advocates a skill inventory application with such components as skills, competency ratings, position profiles, employee profiles and learning events. The SBM application can identify an employee's skill gaps, the distance between the needed skill level and the current skill possessed by the employee. It also facilitates the understanding of relationships between skills and business goals through measures, and then traces and combines skills into job descriptions. The most important objective of SBM is to instill an individual with a greater responsibility for developing his or her valued skills by providing the information resources to define, measure, and achieve the goal.

The tasks of the skills-based manager are listed below:

(1) Interacting with two repositories, as skill inventory and employee profiles, to obtain information about member's possessed skills, competency rating for each skill, and compared with positional profiles to identify skill gaps. Which can be viewed as knowledge-mapping processes in individual level correspond to organizational level.

(2) Providing the matchmaking manager with the

competency ratings of involved skills possessed by the knowledge requester. This attempt may scatter the linking requests to other possible providers with comparatively higher rating than requesters of the involved skills, and by the way to prevent real experts from being flooded with basic questions.

3.1.2 Contribution Manager. Compared with skills-based manager, a contribution manager focuses on encouraging the flux of dialogue based on the theory of social exchange and collaborative filtering concept.

People need incentives to participate in the knowledge sharing process, and thus it is paramount to develop compensation and incentive systems to ensure commitment to the creation and dissemination of knowledge in virtual organizations [17, 44]. To gain insight into how the encouragement of knowledge sharing works, social exchange theory [47] may be applied [25]. Social exchange theory suggests that there is a relationship between a person's affect and his commitment to the relationship. According to social exchange theory, workers will actively contribute and participate in a community if the level of satisfaction with the processes within such a community, as perceived by them, is high. Tiwana and Bush [48] further identify three possible reasons that could underlie the motivation and commitment of community members to their communities:

(1) Anticipated reciprocity: expectation that he will receive actionable information and useful information in return, actionable information has also been appropriately defined as knowledge [10]. The anticipation of future collaboration is also identified as factor to facilitate the development of trust between members [21, 23]. Besides, local participants are also more likely to provide information, since personal social ties are key motivators in providing assistance [27].

(2) Reputation and influence within a community: Rheingold [36] suggests that the effect of one's contributions based upon his reputation within the community can also influence, both positively and negatively, his or her willingness to share relevant knowledge with other members of the community. There are some factors, which may increase a contributor's reputation: high quality information, impressive technical details in one's answers, willingness to help others, and elegant writing.

(3) Perception of efficacy: members are more likely to exert greater effort if one or more of the following three conditions apply: (1) their contributions are identified as being important (2) contributions are personally relevant (3) members perceives a clear relationship between contribution and outcome [42]. This perception of efficacy is defined as a community member's belief that his regular, quality contributions have an impact on his community as a whole, and such contributions add to the contributor's reputation.

Collaborative filtering refers to "sharing knowledge through recommendations" [24] and hence emphasizes the significance of social networks in a virtual environment. To screen out valueless "garbage" and provide high quality information, they proposed several approaches such as to add annotations or ratings to documents they read. The unwillingness to spend some more time to evaluate each article should be a problem. Tiwana and Bush [48] further develop an active collaborate filtering system which contains a contribution manager dedicated to calculate user's contributions compared to total member's contributions in real-time. Through the offering of active feedback, they argue that such a system will encourage knowledge sharing and increase member participation.

Thus, the tasks of the contribution manager are:

(1) Actively providing the comparison of specific employee to the average member's contribution to inspire the willingness to share knowledge with others.

(2) Facilitating the scoring of contribution. The contribution score is judged by the knowledge requester, according to his satisfaction with the help offered by the knowledge contributors, and then stored in employee profiles. Such contribution score may be of help when incorporate into compensation policies.

(3) Facilitating the high quality knowledge to be disseminated. When criticized to be high contribution score, the contribution manager will notify the matchmaking manager to ask the knowledge contributor for the feasibility of the offered knowledge also to be shared to other members with the same skills and competency ratings.

3.1.3 Context Manager. The context manager is designed to smoothen the communication process, and based on the context-based approach and social awareness viewpoint.

A context describes the circumstances surrounding of an act or event. Do, Halatchev, and Neumann [12] proposed a context-based approach to support virtual enterprises and emphasize the importance of context in software engineering. I import the term 'context' here to extend the concept to include the background of people and information. The SIDE theory

suggests that in the absence of individual cues about others, as is the case in computer-mediated communication, individuals builds stereotypical impressions of others based on limited information [30], and the first impression will play an important role to smoothen communication as well as trust-building [23]. Based on transactive memory theory, Rulke and Rau [38] found that newly formed groups spending time discussing their expertise. Hollingshead [19] also learned from a laboratory experiment that when communication is allowed, strangers begin to develop transactive memory system by explicitly establishing relative expertise when working on a knowledge-pooling task. Stasser et al. [43] state that explicit and mutual recognition of expertise and their expert status at the onset of discussion, people can focus their information search and rehearsal on the subsets of information that contain unshared items. Besides, they also suggest the assignment of expert roles facilitated the dissemination of unshared information and the discovery of a hidden profile, and designating persons as expert makes them feel less dispensable and more accountable and results in more effective cognitive processing [46]. These suggestions in line with Ishaya and Macaulay's work [21] about the role of trust in virtual environment, and had full background of others, early identification of roles are significant factors identified by them to build trust.

The importance of contextualization of information provided by other people should not be ignored. Ackerman and McDonald [2] learned from a field study and stressed that providing the contextualization of answers would facilitate the user's understanding of an answer. This implies both geographical proximity and similarity in background can increase the 'absorptive capacity (identified by [9])' between people. Co-location is said to reinforce social similarity, shared values, and expectations [29]. On the other hand, Shenkar and Li [41] classify two types of organizational knowledge, *compatibility* and *complementarity*, when seeking knowledge from prospective partners. People seek additional knowledge in the same domain in which they already have the prior knowledge, and this permits the assimilation and exploitation of new knowledge [9].

In virtual environment, people may have the desire to know the social situation of other members, such as whether they can be disturbed right now. Social awareness is defined as "the understanding of the activity of the others, which provides a context of your own activity [13]". Tollmar et al. [49] indicate social awareness a key element in our everyday work, and people gather continuously information about our colleagues and act accordingly. If they listen, we talk. Kraut et al. [27] point out the knowledge of persons' availability can be physical and emotional. Moran and Andersson [32] also address the importance of signaling the availability of information and people in a way that uses the human capability to peripherally process non-attended aspects.

There are five aspects of virtual interaction. Virtual interaction is aspatial (i.e., not affected by distance), generally asynchronous, acorporal (no co-presence), relatively astigmatic (stigma are markings or behaviors that locate an individual's particular social status), anonymous [7], and accordingly some factors may influence the smooth of communication in virtual environment. The timely exchange of information, frequent interactions, and accurate feedback on each partner's actions will minimize misperceptions and strengthen cooperation in the alliance [20, 23], and providing feedback actively to members is considered as principal factor to influence their behavior and willingness to contribute [48]. Moreover, people may be shy of asking 'stupid' questions and thus in light of the need of mechanism to facilitate asking anonymously [1]. Carver [7] also stressed the importance of humanization when interact in virtual environment. The more complex problem may be the access control policy, for some documentations or knowledge are restricted to share with outsiders, but an overly restrictive information policy will damage trust, hamper learning, and impede the development of interpersonal relationships across organizations [20].

Therefore, the tasks of the context manager are:

(1) Preparing the physical and emotional availability of members for the matchmaking manager. People who face problems mostly have the desire to know the answer as soon as possible. Consider the contexts of possible knowledge contributors; they may remain unavailable due to not being on-line or unwilling to be disturbed. The context manager employs the agent technology to collect such information for better matching.

(2) Providing context information of knowledge contributor. As Stasser et al. [43] states, explicit and mutual recognition of expertise and their expert status at the onset of discussion will helpful for the communication process. People may have several chances talking to strangers through information and communication technologies in virtual organizations. When asking for help, knowledge requesters can see the

background information such as expertise level of the knowledge contributive candidates, and of help to smoothen the onset of dialogue.
(3) Providing background information of knowledge requesters. When being asked for offering knowledge, the possible providers can see the context information about the requesters, includes the purpose of request, expertise level, and contribution score. Being aware of such information, he can determine whether to accept the request, which form or level of knowledge is suited for the requester, otherwise he may feel watchful to share with someone totally unknown. As for sensitive knowledge, he can judge the extant to share.
(4) Allowing knowledge requester to ask anonymously. Sometimes people may be shy of asking 'stupid' questions, and they may choose to request anonymously but not anonymous to the system.

3.1.4 Social Network Manager. Attributing to the involvement of multi-organizations and temporary collaboration character of virtual organizations, social network may have a greater opportunity to be extended faster. The social network manager is responsible for:
(1) Retaining the profiles of possible knowledge contributors. Even when members exit from the ongoing virtual organization, their personal profiles and participation will be kept. They may still act as before to participate in the social network. For the transactive networks system, the only difference is their available priority may go lower but can be accessed when needed.
(2) Facilitating the contextualization of answers. The social network manager may provide matchmaking manager with priorities of serving candidates according to their geographical proximity, by the way to help the understanding of knowledge or facilitate the face-to-face communication.
(3) Capturing the outer linkage to system. When knowledge contributor fails to provide sufficient knowledge, he may recommend some other experts capable to answer beyond the virtual organization. Although insufficient context information, such linkages are also captured to augment the social networks.
(4) Facilitating repeated interaction. Repeated interaction will help to build trust and mutual understanding. When criticized to be high contribution score, the social network manager will provide the knowledge contributive candidate with higher priority to promote the chance of repeated interaction.

3.1.5 Matchmaking Manager. The matchmaking manager serves as an interface between knowledge requesters and contributors and performs essential functions such as:
(1) Parsing the knowledge requests to categorize involved skills by utilizing information retrieval technologies (e.g. knowledge category, please refer to [50]).
(2) Helping the requester to find appropriate contributors. After interacting with other four managers, the matchmaking manager will capable of providing the requester with context information about the smaller, more focused set of contributors, who are ranked to be the highest priority.
(3) Allowing knowledge contributor to selectively share knowledge. With the context information provided by context manager, members may choose to accept or reject the request.

4. Operative Processes in the Transactive Networks Model

The transactive networks operated by the following procedures described in Figure 2:
(1) Each time registered, the personal agent notifies the physical and emotional availability of the member to the context manager. The context manager generates an agent to keep informed about the availability of the member. The physical availability is detected from keystroke or mouse moving by personal agent every certain minute. The emotional availability is determined by the member at any time. He can turn to 'bad mood' if don't want to be disturbed.
(2) The context manager notifies the matchmaking manager to wake up the member's personal skill agents.
(3) The matchmaking manager interacts with skills-based manager and social network manager to obtain lists of personal skill agents labeled as active.
(4) Each member's personal skill agents possess information about the expertise level of the specific skill. In abstract room of skill S_1, personal skill agent of P_2 is absent due to not possessing the skill. On the other hand, personal skill agent of P_4 is labeled as inactive due to not on-line or has been quitted from the virtual organization, and thus being categorized as low priorities.
(5) The skills-based manager may interact with social network manager to generate skill gaps of the member actively.
(6) The contribution manager may interact with

social network manager to generate the contribution report of the members actively.

I'll demonstrate the matchmaking process as shown in Figure 3:

(1) The knowledge requester sends a knowledge request, which is trigger by active or passive learning motivations. He can ask anonymously if intended but won't affect any other processes except display the context information to knowledge contributor without name.

(2) The matchmaking manager interacts with

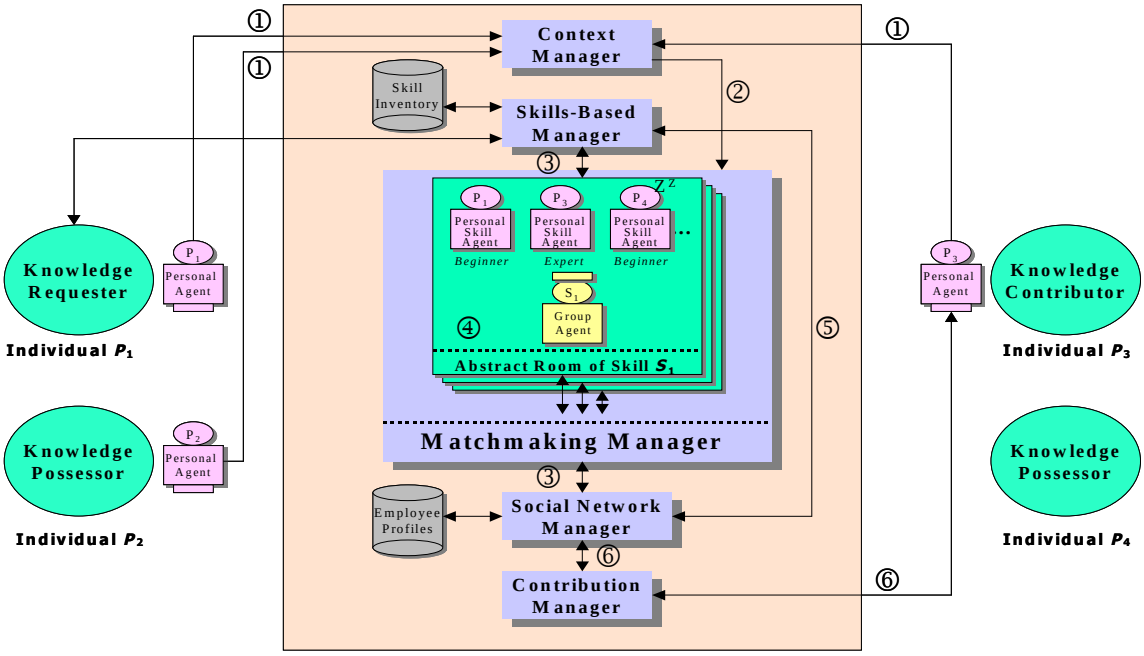


Figure 2. The regular processes of transactive networks model

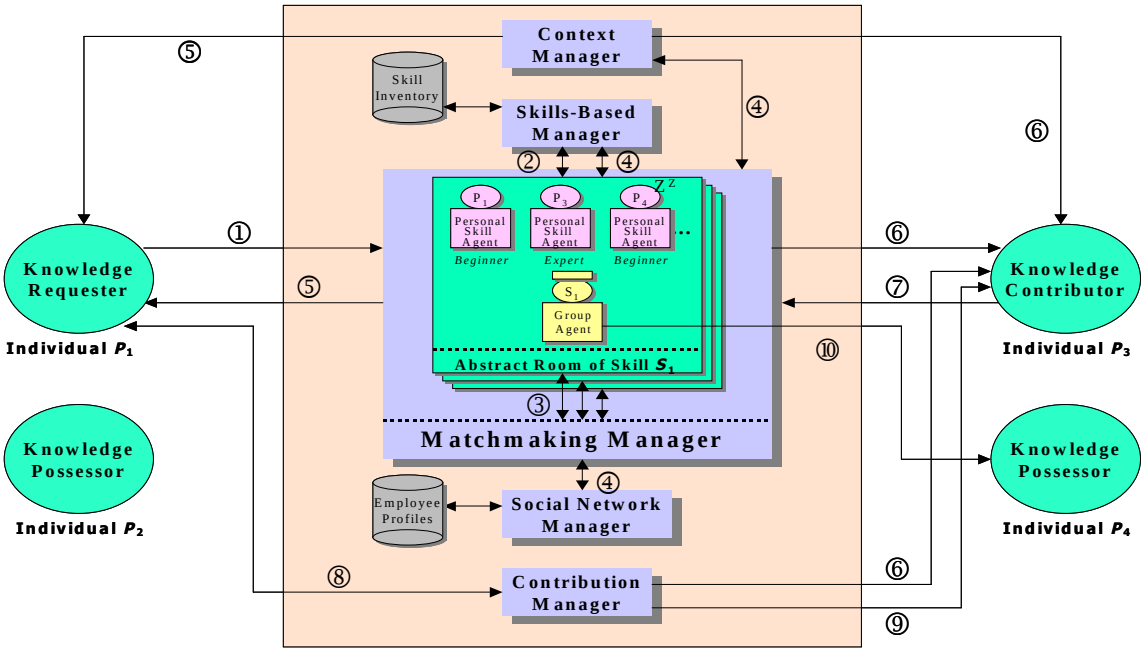


Figure 3. The matchmaking processes of transactive networks model

skills-based manager to categorize involved skills.
(3) The matchmaking agent accesses abstract rooms corresponding to each involved skills to generate a limited list of appropriate contributors in order of priorities.
(4) The priorities are determined by physical and emotional availability provided by the context manager, competency ratings of skills provided by the skills-based manager, and some bonus conditions such as the geographical proximities or repeated interaction provided by the social network manager.
(5) The context information of possible contributor with the highest priority is displayed to the requester. The requester may be asked to select from the limited list of appropriate contributors if intended.
(6) When specific candidate is determined, the requester is asked for keying the purpose of the request. The context information of the requester, purpose of the request, and contribution report are sent together to the designate knowledge contributor.
(7) If accepted, the contributor provided requested knowledge through information and communication technologies or face-to-face communication. Otherwise, the requester chooses another one to ask.
(8) The knowledge requester is asked to score the contribution offered by the contributor each time a matchmaking process is completed.
(9) If criticized to be high contribution score, the contribution manager will notify the matchmaking manager to ask the knowledge contributor for the feasibility of the offered knowledge also to be shared to other members with the same skills and competency ratings.
(10) If the offered knowledge is codified and the contributor permits to share, the group agent of involved skill scans for qualified personal skill agents to disseminate actively.

I hope the transactive networks system will contribute to increasing the flux of dialogue through instilling the desire to learn, inspiring the willingness to broaden accessible individual memory, and smoothening the communication processes.

5. Conclusions and Future Research

This paper proposes the transactive networks model for elaborating knowledge sharing and learning in a virtual organization. It includes five software components as matchmaking manager, skills-based manager, contribution manager, context manager, and social network manager. With the proposed multiagent-based system, I illustrate how it can be of help to connect both knowledge requesters and appropriate knowledge contributors to augment and retain the social networks in fostering virtual organizational learning. In future research, the author will further implement these components and functions for a transactive network. Through the implementation, I can revise the model to make it more feasible for facilitating learning in virtual organizations. The role of trust in virtual organizational learning and the visualization of social networks dynamically are also interesting issues for further studies.

This research was supported by the National Science Council of Taiwan under the grant NSC- 96-2416-H-029-007.

6. References

[1] Ackerman, M. S., "Augmenting Organizational Memory: A Field Study of Answer Garden," *ACM Transactions on Information Systems* (16:3), 1998, pp.203-224.
[2] Ackerman, M. S. and McDonald, D. W., "Answer Garden 2: Merging Organizational Memory with Collaborative Help," In *Proceedings of Computer Supported Cooperative Work '96*, ACM, 1996, pp.97-105.
[3] Antipolis, S., "Organizational Learning and Inter-Firm 'Partnering' in the UK Construction Industry," In *Proceedings of ECLO'97*, France, 1997.
[4] Argyris, C., Schon, D., *Theory in Practice: Increasing Professional Effectiveness*. San Fransisco: Jossey-Bass, 1974.
[5] Boje, D., "The Storytelling Organizations: A Study of Story Performance in an Office-Supply Firm," *Administrative Science Quarterly* (36), 1991, pp.106-126.
[6] Byrne, J.A., "The Virtual Corporation," *Business Week*, 3304, 1993.
[7] Carver, C., "Building a Vritual Community for a Tele-Learning Environment," *IEEE Communications Manazine*, 1999, pp.114-118.
[8] Cohen, M. D. and Sproull, L. S., *Organizational Learning*, Sage Publications, Inc., Thousand Oaks, CA, 1996.

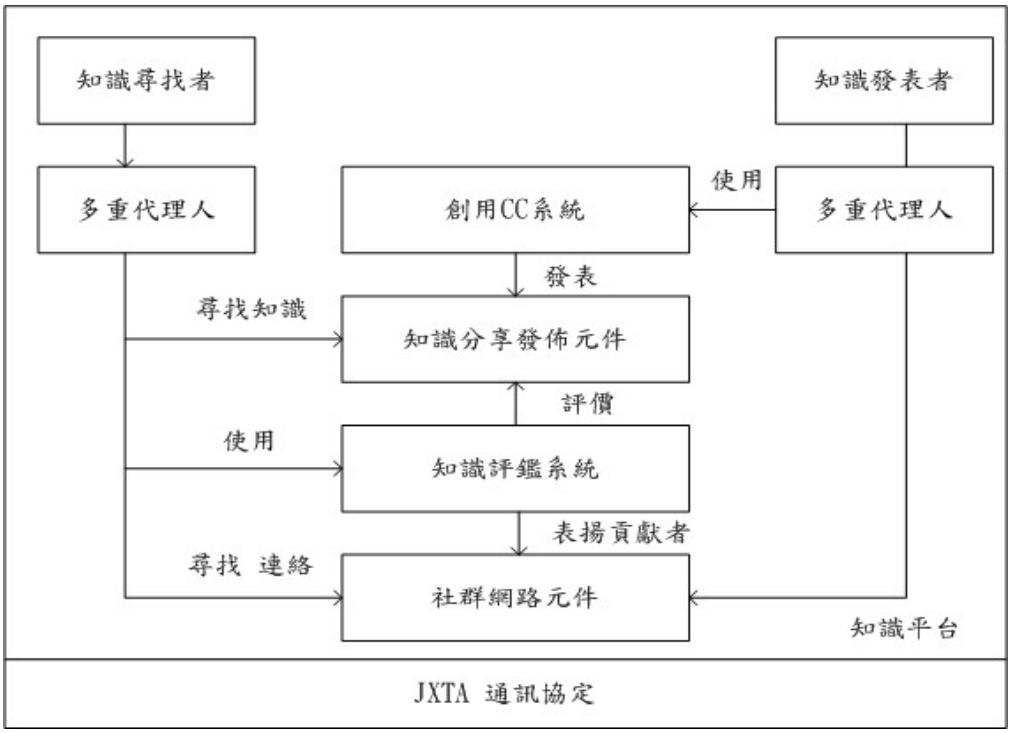
[9] Cohen, W. and Levinthal, D. “Absorptive Capacity: A New Perspective on Learning and Innovation,” *Administrative Science Quarterly* (35), 1990, pp.128-152.
[10]Davenport T. H. and Prusak, L., *Working Knowledge: How Organizations Manage What They Know*, Boston: Harvard Business School Press, 1998.
[11]Dixon, N. M. *The Organizational Learning Cycle: How We Can Learn Collectively*, McGraw-Hill, 1994.
[12]Do, V. T., Halatchev, M., and Neumann, D., “A Contextbased Approach to Support Virtual Enterprises,” In *Proceedings of the 33rd Hawaii International Conference on System Sciences*, IEEE Computer Society, Washington, DC, USA, 2000, 10 pgs.
[13]Dourish, P. and BellottiV., “Awareness and Coordination in Shared Workshops,” In *Proceedings of CSCW’92*, ACM, 1992.
[14]Duncan, R. and Weiss, A. “Organizational Learning: Implications for Organizational Design,” in *Research in Organizational Behavior*, B. Staw (Ed.), Vol.1, JAI Press, Greenwich, CT, 1979, pp.75-123.
[15]Garvin, D. A., “Building a Learning Organization,” *Harvard Business Review* (71:4), 1993.
[16]Hackbarth, G. and Grover, V. “The Knowledge Repository: Organizational Memory Information Systems,” *Information Systems Management*, Summer 1999, pp.21-30.
[17]Hansen, M. T. Nohria, N. and Tierney T., “What’s Your Strategy for Managing Knowledge?” *Harvard Business Review* (77:2), 1999, pp.106-116.
[18]Hattori, F., Ohguro, T., Yokoo, M., Matsubara, S., and Yoshida, S., “Socialware: Multiagent Systems for Supporting Network Communities,” *Communication of the ACM* (42:3), 1999, pp.55-61.
[19]Hollingshead, A. B. “Retrieval Processes in Transactive Memory Systems,” *Journal of Personality and Social Psychology* (74:3), 1998, pp.659-671.
[20]Hutt, M. D., Stafford, E. R., Walker, B. A., and Reingen, P. H., “Case Study: Defining the Social Network of a Strategic Alliances,” *Sloan Management Review* (41:2), 2000, pp.51-62.
[21]Ishaya, T. and Macaulay, L., “The Role of Trust in Virtual Teams,” *Electronic Journal of Organizational Virtualness* (1:1), 1999, pp.140-157.
[22]Jain, A. K., Aparicio IV, M., and Singh, M. P., “Agents for Process Coherence in Virtual Enterprises,” *Communications of the ACM* (42:3), 1999, pp.62-69.
[23]Jarvenppa S. L. and Leidner, D. E., “Communication and Trust in Global Virtual Teams,” *Journal of Computer-Mediated Communication* (3:4), 1998.
[24]Kautz, H., Selman, B., and Shah, M., “Referral Web: Combining Social Networks and Collaborative Filtering,” *Communications of the ACM* (40:3), 1997, pp.63-65.
[25]Ke, W. and Wei, K. K., "Critical factors affecting the firm to share knowledge with trading partners: a comparative exploratory case study," In *Proceedings of the 7th international conference on Electronic commerce*, 2005, pp.177-183.
[26]Kim, D. H. “The Link between Individual and Organizational Learning,” *Sloan Management Review* (35:1), Fall 1993.
[27]Kraut, R., Egido, C., and Galegher, J., “Patterns of Contact and Communication in Scientific Research Collaboration,” *Intellectual Teamwork*, Lawrence Eribaum, Hillsdale, NJ, 1990.
[28]Kraut, R., Steinfield, C., Chan, A., Bulter, B., and Hoag, A., “Coordination and Virtualization: The Role of Electronic Networks and Personal Relationships,” *Journal of Computer-Mediated Communication* (3:4), 1998.
[29]Latane, B., Liu, J. H., Nowak, A., Bonevento, M., and Zheng, L., “Distance Matters: Physical Space and Social Impact,” *Personality and Social Psychology Bulletin* (21:8), 1995, pp.795-805.
[30]Lea, M. and Spear, R., “Paralanguage and Social Perception in Computer-Mediated Communication,” *Journal of Organizational Computing* (2:3&4), 1992, pp.321-341.
[31]Liebeskind, J. P., Oliver A. L., Zucker, L., Brewer, M., “Social Networks, Learning, and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms,” *Organization Science* (7:4), 1996, pp.428-443.
[32]Moran, T. P., and Anderson, R. J., “The Workday World as a Paradigm for CSCW,” In *Proceedings of CSCW’90*, ACM, 1990.
[33]Nonaka, I. “A Dynamic Theory of Organizational Knowledge Creation,” *Organization Science* (5:1), Feb 1994, pp.14-37.
[34]O’Leary D. E., Kuokka, D., and Plant, R., “Artifical Intelligence and Virtual Organizations,” *Communications of the ACM* (40:1), 1997, pp.52-59.
[35]Pedler, M., Burgoyne, J., and Boydell, T., *The Learning Company: A Strategy for Sustainable Development*, McGraw-Hill, Maidenhead, 1991.
[36]Rheingold, H., *The Virtual Community: Homesteading on the Electronic Frontier*, New York: Addison-Wesley, 1993.

[37]Riehl, H. “Managing with Skills,” *Ivey Business Journal* (62:4), 1998, pp.50-54.
[38]Rulke, D. L. and Rau, D. “Examining the Encoding Process of Transactive Memory in Group Training,” *Academy of Management Proceedings*, 1997, pp.349-353.
[39]Schein, E., “On Dialogue, Culture and Organizational Learning, “ *Organizational Dynamics*, 1993, pp.40-51.
[40]Seufert S. and Seufert, A., “Towards the Continuously Learning Organization through Knowledge Networking – Case Swiss Re Group,” In *Proceedings of the 33rd Hawaii International Conference on System Sciences-2000*, IEEE, 2000, 11 pgs.
[41]Shenkar, O. and Li, J. “Knowledge Search in International Cooperative Ventures,” *Organization Science* (10:2), 1999, pp.134-143.
[42]Shepperd, J., “Productivity Loss in Performance Groups: A Motivation Analysis,” *Psychological Bulletin* (113), 1993, pp.67-81.
[43]Stasser, G., Stewart, D. D., and Wittenbaum, G. M., “Expert Roles and Information Exchange during Discussion: The Importance of Knowing Who Knows What,” *Journal of Experimental Social Psychology* (31), 1995, pp.244-265.
[44]Steil, A. V., Barcia, R. M., and Pacheco, C. S., “An Approach to Learning in Virtual Organizations,” *Electronic Journal of Organizational Virtualness* (1:1), 1999, pp.69-88.
[45]Stein, E. W. and Zwass, V. “Actualizing Organizational Memory with Information Systems,” *Information Systems Research* (6:2), 1995, pp.85-117.
[46]Tetlock, P. E., “Accountability: The Neglected Social Context of Judgment and Choice,” In L. L. Cummings & B. M. Staw (Eds.), *Information and Cognition in Organizations*, Greenwich, CT: JAI Press.
[47]Thibaut, J, and Kelley, H., *The Social Psychology of Groups*, NewYork: Wiley,1959.
[48]Tiwana, A. and Bush, A., “Peer-to-Peer Valuation as a Mechanism for Reinforcing Active Learning in Virtual Communities: Actualizing Social Exchange Theory,” In *Proceedings of the 33rd Hawaii International Conference on System Sciences-2000*, IEEE, 2000, 10 pgs.
[49]Tollmar, K., Sandor, O., and Schomer, A., “Supporting Social Awareness @ Work Design and Experience,” In *Proceedings of CSCW’96*, 1996.
[50]Tu, H. C. and Hsiang, Jieh, “An Architecture and Category Knowledge for Intelligent Information Retrieval Agents,” In *Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS'98)*, IEEE, 1998.
[51]Walsh, J. P. and Ungson, G. R. “Organizational Memory,” *Academy of Management Journal* (16:1), 1991, pp.57-91.
[52]Wegner, D. M. “Transactive Memory: A Contemporary Analysis of the Group Mind,” In B. Mullen & G. R. Goethals (Eds.), *Theories of Group behavior*, New York: Springer-Verlag, 1986, pp.185-208.
[53]Wegner, D. M. “A Computer Network Model of Human Transactive Memory,” *Social Cognition* (13), 1995, pp.319-339.
[54]Wijnhoven, F., “Development Scenarios for Organizational Memory Information System,” *Journal of Management Information Systems* (16:1), Summer 1999, pp.121.
[55]Zucker, L., “Markets for Bureaucratic Authority and Control: Information Quality in Professions and Services,” *Research in the Sociology of Organizations* (8), 1991, pp.157-190.

計畫成果自評：

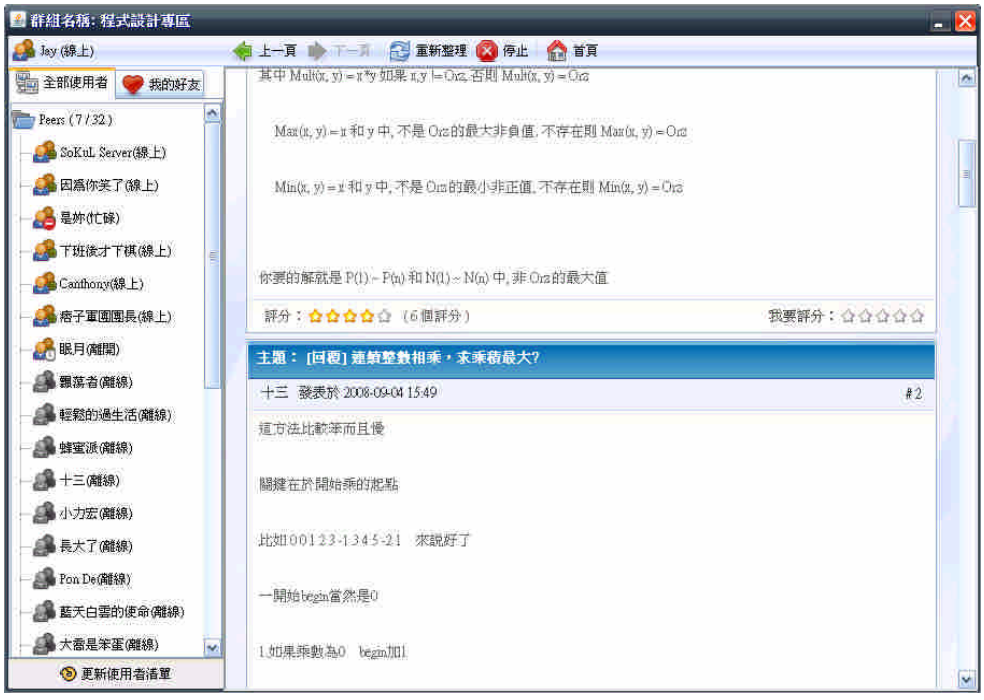
本研究內容與原計畫完全相符，並已發表於 IEEE 舉辦之 *41th Annual Hawaii International Conference on System Sciences (HICSS2008)論文集*(EI)。

為了增加研究結果的應用性，本人依照本論文架構帶領學生建置 CCECPN (Creative Commons Embedded Collaborative Peer-to-peer Network)平台，其系統架構如圖一所示，包含許多本論文所提之系統元件。至於創用 Creative Commons 元件，則是有鑑於目前點對點網路的發展多受制於智慧財產權，因此有必要新增此一元件在互動網路系統，系統畫面如圖二與圖三。本系統業已建置完成，已報名參加今年的全國大專軟體設計大賽。未來可依此系統進行實驗以收集實證資料，可以作為本論文的衍生後續研究，並打算整理後投稿資管領域的學術期刊。



圖一、CCECPN 系統架構

圖二、CCECPN 系統進站畫面



圖三、對其他使用者分享的知識做適當評分。

附註：出席國際學術會議心得報告已另上傳至國科會網站繳交