CHAPTER 3

METHODOLOGY

3.1 Introduction

The research proposes the model of "Double Spiral" as the main conceptual idea of the research methodology. This means that the processes of software development and knowledge creation have to be done simultaneously and spirally so that the developed KMS will meet the individual objectives while new experience/ knowledge will increase throughout the cycle of business process. The double spiral approach is based on the assumption that user requirements are more concern with collaborative tacit knowledge among clustering members throughout the business process cycle. Therefore, repetitive processes with incremental system prototype are practical in that requirements are suppose to be changed or increased at the end of cluster business process cycle.

As discussed in Chapter 2, SMEs cluster has significant roles to local and national economic growth. According to Bell and Albu (1999), the dynamism of cluster which refers to the interdependency among members is one of the key factors for its long term competitiveness. "Technological" and "Social" aspects are the drive forces of the dynamism. Technology provides tools of storing and accessing knowledge-based system while the social plays an important role for the development of knowledge transfer. New knowledge is then created through knowledge conversion process which in turn contributes to innovation (Cooke, 2002; Porter, 1998).

The concept of KM on cluster dynamics is to bring participants together in the same place to share ideas and collaborate toward the desired outcome. This requires the development of an effective KMS that will optimize the individual needs. Web-based KMS is one of practical approaches that support communities' sharing by linking and providing members 24-hour access to knowledge repository. However, most web-based KMS usually employ services of pull-based technology such as search system, updated information depends on every time users access to needed information. Web 2.0, known as second generation of web, is preferred to use in collaborative learning and knowledge sharing via social networking sites. Moreover, Davenport, et al. (1998) recommends that an efficient KMS must be able to response to the stages of KM process:

1. Knowledge generation (who share knowledge and why? how is it captured?)
2. Knowledge codification (how is knowledge organized?)
3. Knowledge transfer (how is knowledge shared?)

To develop the KMS for SMEs cluster therefore requires a systemic software process that supports all stages of KM process and also meets all individual needs. Although there are various software process models that can be applied, they are not entirely suitable in the SMEs cluster context due to several reasons:

1. The industrial cluster includes different types of users (e.g. core members, CDA, academicians, and related supporters, etc.) which have different roles in cluster. Each type of users perceives and requires different knowledge from the KMS. Developing an effective KMS requires the analysis and design process that must be response to the dynamics of individual users' requirements.

2. Industrial cluster represents social network which has the tendency of informal interactions among members. They usually participate in different activities and events of cluster process cycle. As a result, KMS must be designed and developed based on various activities and events that they involve throughout the cycle.

There is no exact solution of KMS that fit all SMEs clusters. However, the system must be able to response to the dynamic requirements from users at different time during the development of the system. To accomplish this, the combination of knowledge management approach and software engineering approach is adapted. In knowledge management approach, knowledge is transferred during knowledge conversion process. At the same time, in software engineering approach, requirements elicitations are performed during the design and development of the system. This will be done along the business process cycle based on the evolutionary model. Therefore, the purpose of methodology aims at applying knowledge management practice and software engineering practice to the development of dynamic KMS for SMEs cluster. The steps of proposed methodology are shown in Table 3.1.

Table 3.1 Proposed methodology for the development of dynamic KMS

Steps	Tools and Techniques	Expected Results
Identification of Key Players	Social Network Analysis (SNA)	Qualified key players for JAD
Design of Workshop and Requirement Analysis	Joint Application Development	Session war room for participative development and decision making, Requirement specification
KMS Design and Development	Evolutionary Model Web 2.0, CSS	Web-based KMS (incremental prototype)
Learning in Action	Double Spiral: (Knowledge Spiral+ Software Spiral)	New experience, new knowledge
KMS Evaluation	Questionnaire and Demonstration Test	Users' feedback and suggestion

The first step of methodology will select cluster key persons to work with IT persons in the analysis stage. SNA is used at this step because it identifies and visualizes pattern of network relationship. A person who relates with others in terms of number of nodes and ties is considered to be a key player. The design of workshop and requirement must be prepared in an informal atmosphere. Joint Application Development (JAD) is the technique used to accompany with stakeholders involving the system development. Informal meeting room, time sessions and good facilitator are the key of success. During the KMS design and development, an evolutionary model using web technology and tools is adapted. This approach is suitable when the requirement is hard to identify and social networking WEB 2.0 is widely used in the collaborative environments. CSS is selected for the dynamic design purposes as the web page presentation can be customized easily. The step of learning in action applies the double spiral model to integrate software engineering process with knowledge creation process. This will increase the contents of system prototype and knowledge in every JAD session. The final step is the suggestion of the system for the repetitive cycle of JAD next year. This is to response with the speed and changes in SE technology and new knowledge of business process to develop an incremental version of prototype intelligently.

As described earlier, an efficient KMS must response to all KM stages: knowledge generation, knowledge codification and knowledge transfer. According to the methodology step, knowledge generation is the stage of identifying key players of knowledge domain and how to acquire knowledge from them. In general, industrial cluster which is socialized loose network comprises various types of enterprises and members whose objectives and requirements are different. To develop the system that meets all users' requirements is difficult task. Instead, selecting key players that represent all types of enterprise members gives more chances of system success especially during the step of knowledge elicitation. SNA is the KM tool used at this stage as its result visualizes the pattern of network relationship so that key players can be identified.

Knowledge codification means converting tacit knowledge to explicit knowledge in a usable form. At this stage, requirements must be captured from the selected key players for the analysis and design of the system. However, it is difficult to codify knowledge at one time from different types of users whose tacit knowledge is different and requirements is difficult to explain. Therefore, knowledge codification must be done in parallel to the software development process. Evolutionary model is adapted for system development to help users visualize and conceptualize their requirements from the prototype. Web 2.0 as platform and CSS technique is used for rapid prototype development. In addition, JAD technique is used to obtain group consensus on problems, objectives, and requirements during system planning and analysis. The real benefit of JAD is the involvements of users, managers, and IT specialists in a single room for an extended period of time (four to eight hours per day, anywhere from one day to a couple weeks). Therefore, using evolutionary model and JAD technique is appropriate to the development of KMS for industrial cluster context.

Knowledge transfer means the spread of knowledge to larger groups. Sharing of knowledge must be managed so that new knowledge will be created. At this stage, the system has been used and internalized to all users' tacit knowledge. In most cases of ceramic cluster, collaborations are mostly event or activity-based and repeated cycle. Therefore, knowledge sharing is very important since new knowledge from past experiences will cause the upcoming events or activities more productive. An iterative software process is redone for the improvement of the incremental version of prototype. The technique of "Double Spiral" which synchronizes the model of knowledge spiral (Nonaka and Takeushi, 1995) and software spiral model (Boehm, 1988) is used. There is a harmonization between the two models in terms of the 4-quadrant repeating steps and the incrementing objective which must be done in parallel for the progression and completion of the system.

3.2 Identification of Key Players

One of the most difficult tasks in the collaborative system is to motivate users to use and share information and knowledge. Even harder task is to make them use the system in a sustainable way. The research on successes and failures of software projects in the United States (US) done by the Standish Group's Chaos has shown that three major reasons of project failure include: lack of user involvement (12.8%), incomplete requirements and specifications (12.3%), and changing requirements and specifications (11.8%) (The Standish Group, 1995). Hence, it is essential to know "who" the key players and "what" kinds of knowledge are to be managed. Identifying the proper users who understand their requirements and willing to work with JAD team during system analysis and design is a crucial step. The necessity to identify key players (e.g.: knowledge workers) as part of business processes within their work environment is important due to the fact that they function well within such environments. Many studies have shown that relationships among individuals are the key to cluster genesis and effective functioning, therefore, it is important to examine social network among clustering members where knowledge is interacted and shared.

Table 3.2 Stages of identification of key player

Steps	Methods and Tools	Expected Results
Identification of Network Key Players	Reputation approach: expert recommendation	Network key players
Collection of Data	Questionnaire, Expert interview	Social network data
Analysis of Network Data	Graph theory SNA software: UCINET	Social network relationship model Patterns of people interaction
Interpretation of results	Analytical approach: Degree centrality	Qualified key players for JAD (Key knowledge network)

Table 3.2 shows the steps of identification of key players. To identify social network in cluster, reputation method where a list of participants is proposed by knowledge expert (e.g.: cluster leader) is adopted ("snowballing"). This approach is useful for the analysis of networks across organizational boundaries (Müller-Prothmann, 2007). Based on Porter's definition, industrial cluster comprises core firms, government and supporting sectors along the supply chain of industry. A chain of network is therefore developed from the originated key player of each member type. For example, as shown in Figure 3.2, the starting point of "core member1" who represents the key player of core firms recommends his/her social network including core member2, core member3, and CDA while CDA who represents the key player of government agents recommends core member4, supplier1 and also refers back to core member1. Similarly, key player from other sectors will select and recommend his or her network. Moreover, in the real situation, intensity of relationship is considered to illustrate the strength of tie between actors whether it is strong, medium, or weak. The strength of tie is dependent based on the amount of time, the emotional intensity,

the intimacy and the mutual services. This simply means that the better two members know each other in terms of friendship, assistance, the stronger the tie is.

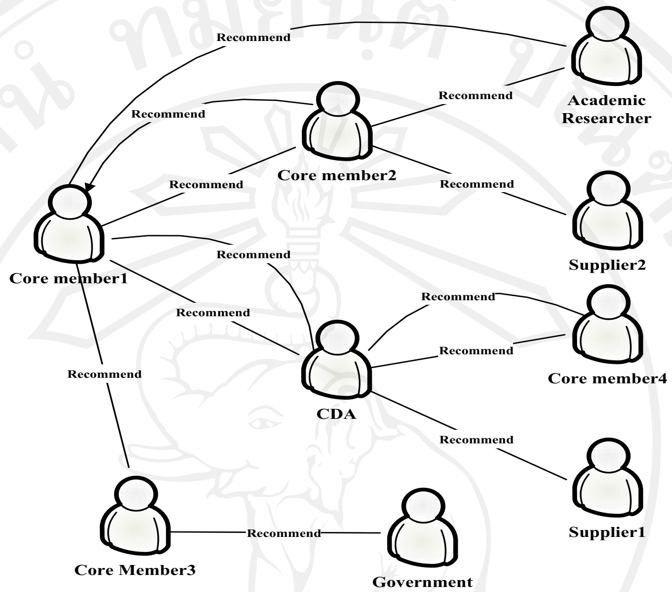

Figure 3.1 A chain of network in cluster

To analyze network, SNA is a common method used to evaluate the availability and distribution of critical knowledge. It is also used to figure or visualize the patterns of interaction by examining the informal relationships among network members. SNA is applied in many cases of industry cluster to understand linkage among clustering members (Bergman and Feser, 1999). Recently, SNA has become a strategic tool for expert localization, identification of knowledge communities and analysis of the structure of intra- and inter-organizational knowledge flows. The SNA results give leaders the picture they need to create a set of actions for individuals and groups to improve organizational productivity, efficiency and innovation.

Firstly, data must be collected from network key players. Questionnaires are submitted to 30 key players to ask about the relationships and strength of relationships among them. Figure 3.3 is a part of questionnaire design sample. The social network data is then analyzed using social network software which this research use the UCINET application. Three basic measurements of social network relationship include degree centrality, closeness centrality, and betweenness centrality. By calculating the degree centrality, it is possible to illustrate the role of an individual within the cluster. Central people who have more influence in their network tend to be more satisfied with their jobs than people who are less central. Figure 3.4 shows the degree centrality of ceramic cluster in Lampang while Figure 3.5 is the visualization of social network.

Cluster Types	**Person Name you collaborate and share knowledge (List in priorities of maximum 3 persons)**	**Frequency of Communication/ Collaboration**			**Satisfactory Level of Communication/ Collaboration**					**Types of Communication/ Collaboration**	
		1-2 per Month	1-2 per week	Always	Maximum				Minimum	Give consult	Receive consult
					5	4	3	2	1		
Core Cluster	(1)...................										
	(2)...................										
	(3)...................										
Suppliers	(1)...................										
	(2)...................										
	(3)...................										
Government Agencies	(1)...................										
	(2)...................										
	(3)...................										

Figure 3.2 Questionnaire design samples

		Degree	NrmDegree	Share
14	Anurak	21.000	20.000	0.164
5	Pornsawan	17.000	16.190	0.133
1	Sophon	17.000	16.190	0.133
17	Paitoon	17.000	16.190	0.133
2	Raewat	10.000	9.524	0.078
12	Surapon	5.000	4.762	0.039
25	Adhipoom	3.000	2.857	0.023
4	Suraporn	3.000	2.857	0.023
18	Nalongkorn	3.000	2.857	0.023
13	Krith	3.000	2.857	0.023
8	Warakorn	3.000	2.857	0.023
6	Nopasit	2.000	1.905	0.016
3	Nipon	2.000	1.905	0.016
36	ATSME	2.000	1.905	0.016
21	LIF	2.000	1.905	0.016
7	MTEC-Somnuk	2.000	1.905	0.016
29	S-MS	1.000	0.952	0.008
28	S-MRD	1.000	0.952	0.008
15	Khatawut	1.000	0.952	0.008
20	LCA	1.000	0.952	0.008
19	Prasong	1.000	0.952	0.008
22	WangKwang	1.000	0.952	0.008
32	LPAO	1.000	0.952	0.008
33	Sci-Lada	1.000	0.952	0.008

Figure 3.3 Degree centrality of ceramic cluster in Lampang

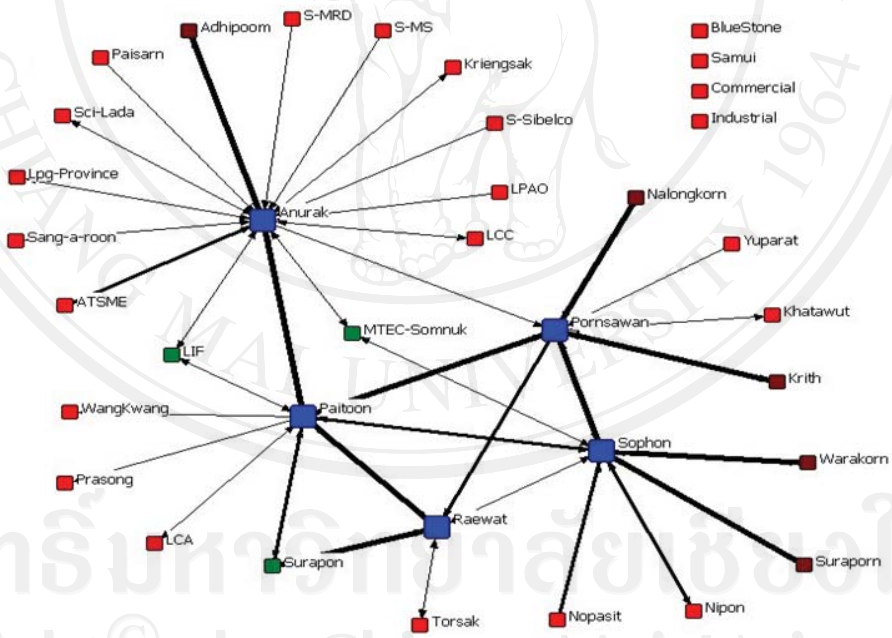

Figure 3.4 Visualization of social network of ceramic cluster in Lampang

Based on the data analysis, the blue rectangle bullets which have high degree centrality are selected as the qualified key players that will be part of JAD teamwork in the next step.

3.3 Design of Workshop and Requirement Analysis

This step is to prepare the environmental factors concerning the software development so that the final system will be move forward and successful. The concept of JAD which is based on group sessions of key persons is adapted. JAD is a workshop approach to system analysis and design where the primary users involve the special prepared meetings called “JAD session”. In JAD session, all users involving the software development are called “JAD team”. They generally come from different units or organizations with different backgrounds, different levels of experiences, and different requirements. This step aims at the process of requirement elicitation from JAD members to prepare the requirement specifications to be used in the next step.

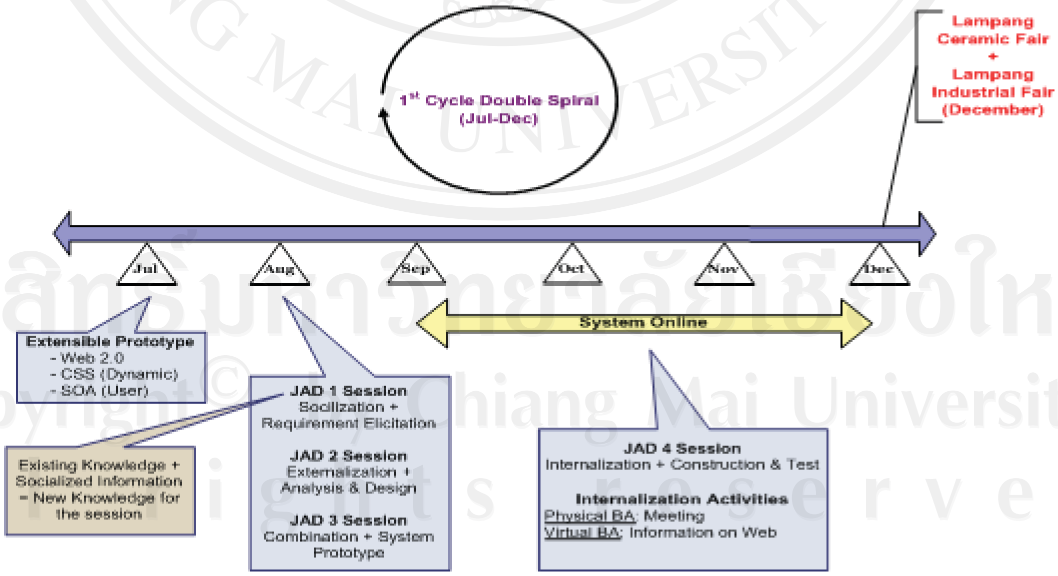

Figure 3.5 JAD framework applied to Lampang ceramic fair

To be successful in JAD session, key players who understand the business process and willing to be the member of the JAD team as discussed in the previous section are selected. The cost and time of determining business requirements is therefore significantly reduced and quick. JAD framework is applied to the case of Ceramic Fair event in Lampang province, Thailand is shown in Figure 3.6 It shows only the first cycle of double spiral with JAD between July and December applied to the "Lampang Ceramic Fair" business process. In Similar, the next cycle of double spiral with JAD will be conducted between November-April to handle the business process of "Bangkok International Gift and Bangkok International Household/ BIG&BIH" event.

Table 3.3 JAD session based on 4-stage of SECI and software process

JAD Session	**JAD Steps**	**KM and SE Processes**	**Tools and Techniques**	**Expected Results**
Pre-JAD	Mobilization	Market Survey	Document Analysis Expert Interview	Business Problem, Initial vision & Objectives
JAD #1	Diagnosis	Socialization + Requirement Elicitation	Requirement Workshop, Use Cases, Extensible Prototype	Business Process and Requirements from experiences
JAD #2	Initiatives	Externalization + Analysis & Design	Activity Diagram	Business Process, Functional Spec. in conceptual design
JAD #3	Implementation	Combination + Construction and Test	Use Case Diagram Web 2.0 + CSS	Scenario Use Cases System Prototype in detailed design

Table 3.3 (continued) JAD session based on 4-stage of SECI and software process

JAD Session	JAD Steps	KM and SE Processes	Tools and Techniques	Expected Results
JAD #4	Online Operation	Internalization + Next Iteration Planning	Meeting Questionnaire Expert Interview	New Information and Knowledge

The JAD session agenda and the complete or clean JAD room are well-prepared. In this research, JAD session is divided into 4 sub-sessions (JAD session 1-4) corresponding to the 4 stages of knowledge conversion process (socialization, externalization, combination and internalization- SECI) and software development process. The event of Lampang ceramic fair is used to conduct JAD sessions. Each JAD session, steps, processes, tools and techniques and the expected result of each session are shown in Table 3.3.

Pre-JAD Session

Before the JAD session begins, the responsible business analysts (people who know well in business process) in the JAD team identify the problems or risks and define the system scope. In performing these tasks, document analysis and expert interview are the tools used to identify the existing problems from previous experiences of business processes. Mobilizing through market survey from both core members and customers also gives advantages. At this stage the business problems, visions and objective can be identified.

JAD #1 Session

The first JAD session begins with a workshop to capture high-level business requirements which will be used to describe the business process workflow in the next stage. The requirement workshop and use case can accelerate the elicitation process to acquire the requirements from sharing tacit knowledge. The main purpose is to capture consensus based business requirements and provide the developers with a good understanding of what the business wants the system to do. Use Case requirements usually identifies the main flows, business rules, and design constraints. Use Case diagram is easily understood by participants in group sessions. During the session, people who deal with the business process or use the system (the actors), analyze how systems are used to get real work done (the Use Cases). Use Cases are described and then expanded to an appropriate level of details in an iterative process. Through elaboration of the Use Cases, business requirements are thoroughly explored, fully understood and documented. By using JAD requirement workshop and Use Case analysis, tacit knowledge can be shared among JAD participants so that common tacit knowledge can be acquired. Extensible prototype must be involved and demonstrated so that all JAD members can visualize and easily extract their tacit requirements.

JAD #2 Session

This session starts with the review of the concept of operations in the first JAD session. The purpose is to translate the business requirements into the system functional requirements. Activity diagram is used to visualize the workflow of a business use case and functional specifications can be designed for each business process scenario. Through externalization, common tacit knowledge is translated into conceptual explicit knowledge. From the software spiral view, the result is system specifications from the analysis and design stage.

JAD #3 Session

At this stage, it is responsibility of JAD team to draft a system prototype supporting different scenario use cases. Use Case diagram is a required tool. An incremental version of system prototype is added to the existing prototype as the double spiral moves to the next cycle. Rapid development approach is applied so that each prototype will be finished within time schedule. Web 2.0 and CSS are useful tools for system construction and testing. As users involve throughout the system development stages, the proper system prototype will be generated.

JAD #4 Session

Once the system prototype is put on-line, internalization process is started. By collaborating and sharing information through the use of system, cluster members will learn from their experiences. Activities such as physical meeting should be conducted to measure what they learn from the system through the end of JAD #4. The next cycle will start again by reviewing goals and risks and planning for the next JAD session.

3.4 KMS Design and Development

There is an increasing demand for the development of web-based applications, while the tendency is to fulfill the needs of more and more users. For the community and collaborative software where many users involve the system in terms of creating and extracting web-content, the provision of solutions and technologies to develop more dynamic web-applications is essentially required. Moreover, different types of users have different requirements of system functions. With web 2.0 as platform, a user-generated support system and socialized network services (SNS) allows individuals and social network groups to manage and maintain information independently. By using the Cascading Style Sheet (CSS) technique, request-to-response web pages can be achieved individually. Therefore, the design and development of system must be able to response to the dynamic of users' requirements and to fulfill their personalized needs.

Firstly, to meet individual users' needs, the system provides several services that support users in 3 important aspects: *response, time, and event*. User generally wants to express his or her need to a system and then the system must *"response"* the right information to the user. Search engine of Google website is a good example. To achieve this in cluster, the qualified users must involve in system development especially in the analysis and design step to disclose their requirements. Even if users do not express their needs, needed information should automatically transfer to them every time they log on the system. Therefore, a webpage must be designed based on individuals' needs. For example, the contents of web for managers may include information about market, finance and product trends while knowledge workers require different information such as production and technical knowledge. Push technologies are useful tools for this purpose. "Push" (or "server-push") is the delivery of information on the Web that appears to be initiated by the information server rather than by the information user or client, as it usually is. For the dynamics of *"time"*, the webpage should vary through the "time" frame of business process activities. As time changes, webpage should be automatically changed according to the process activities of business. Figure 3.7 shows the one-year cycle of business process in the cluster based on data survey from cluster key players. CSS is the preferred tool for this purpose as different CSS can be designed to match the different business process requirements. The advantage is not only to remind each member and react to the concerning joint activities process but to motivate them to use the system as it serves as an automatic year plan for individuals.

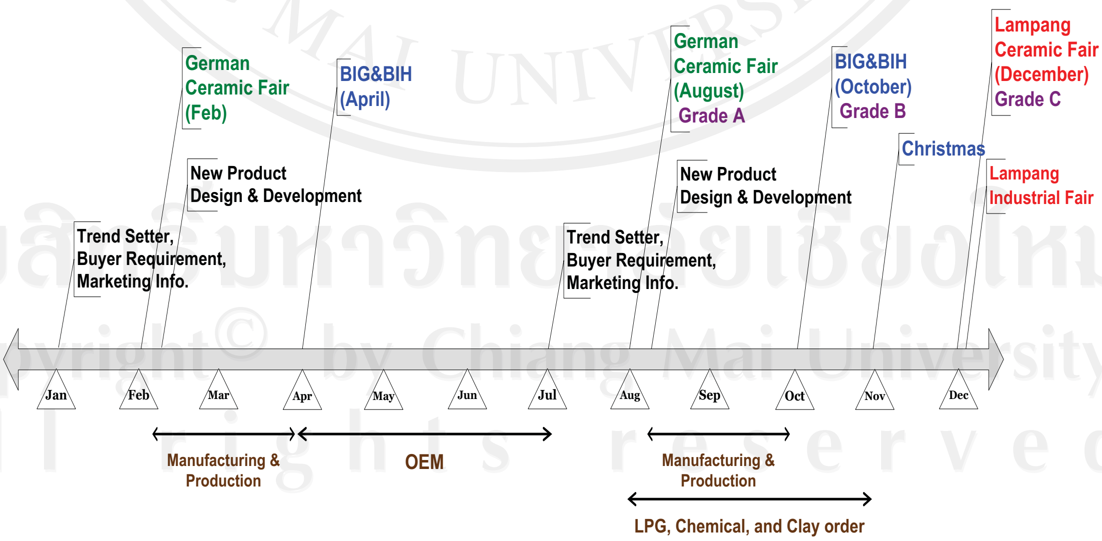

Figure 3.6 Business process cycle of ceramic cluster

The system should also provide the capability of *"event"* management. Either planned or unplanned information, private or public information must be easily managed and customized by groups or individuals. Hence, participants will get the right information at the right time from the dynamic web. By this way, collaborations and knowledge sharing in virtual communities (vCoPs) will be performed in a sustainable way. Collaborative services of Web 2.0 such as Blogs, Wikis, Calendar, FAQ, SNS, RSS, search engine and dynamic FAQ are examples of web tools. The dynamic design architecture for system prototype is shown in Figure 3.8.

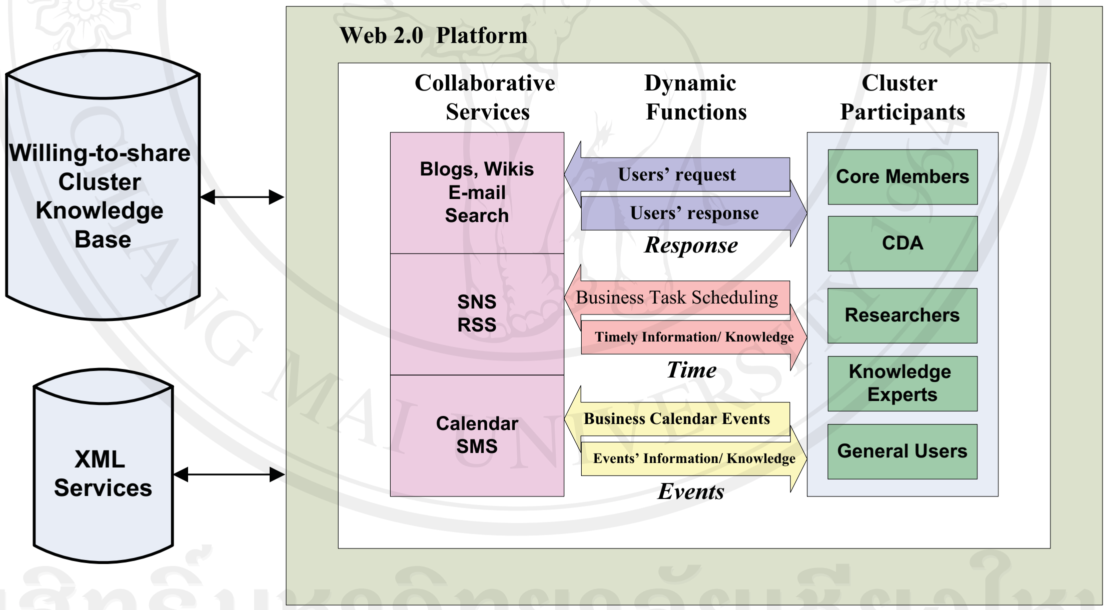

Figure 3.7 Dynamic design architecture for system prototype

From Figure 3.10, different cluster participants require and willing to share different information and knowledge. Sureephong (2008) recommended that the collaboration and knowledge sharing in cluster will be developed only if members are willing to share the information which he proposed the 4-layer knowledge sharing model: collaboration layer, cluster layer, community of practice layer, and proprietary layer. The system is designed to support 3 layers except the proprietary layer. For the collaboration layer, members are willing to share information and knowledge to all users. Search tool is commonly used so that users can easily search and get the right information. For cluster layer, only willing information and knowledge in the same value chain can be shared. Discussions and Wikis are effective tools for the publishing of information. Calendar and supportive information via other web links should be updated to each member's webpage. For the community of practice layer, only participants within the same CoP are willing to share and exchange information and knowledge. SNS and web board is applied for this purpose.

3.5 Learning in Action

Knowledge Management implies that knowledge can be managed. Many authors define KM as a process of "creating, capturing, storing, sharing, and reusing" knowledge (Davenport, et al. 1998; Wiig, 1997). Nonaka (1994) recognizes that KM is the dynamic process of interaction between tacit and explicit knowledge. There have been many models of KM (Chua, 2004). Nonaka (1994) proposes a spiral model of dynamic interaction between tacit and explicit knowledge and characterize four processes called SECI (socialization, externalization, combination and internalization) that amplify individual knowledge to organizational knowledge. The flows of knowledge through SECI are supported by different four triggers: field building, dialog, linking explicit knowledge, and learning by doing so that new knowledge can be created. The deployment of IT and IS to develop KM systems is the key factor of KM success as they are tools to encourage those triggers.

Effective KM systems must be managed by learning from past experiences in a cyclical approach as requirements are too complex and difficult to understand to fit in a simple development approach (Schreiber et al., 1999). KM systems for cluster are in the same situation. The spiral method generally repeats and revises the same steps of system development in a cyclical approach. Originally proposed by Barry W. Boehm in 1988 (Boehm, 1988), the spiral model is based on an evolutionary approach using prototyping technique to resolve any uncertainties of requirement specification. In contrast to the waterfall model which has sequence activities, the spiral model has repetitive process which combines the good features of the prototyping model and the waterfall model approaches. Hence, each loop in the spiral represents a phase of the software process. In the real-world practices where there are many uncertainties or risks, the software spiral approach and knowledge spiral are mutually integrated during system development for several reasons:

1. Software spiral and knowledge spiral are similar in two aspects: the number of process stages and the nature of cyclical approach.

2. Software spiral is one of good approaches to develop KM systems where knowledge or requirements is hard to explain but gradually increase with the incremental version of prototype.

In case of the development of KMS for ceramic cluster, team developers have to deal with users' risks such as the uncertainties of system objectives and requirements. Software spiral helps developers in solving the risk problems while knowledge spiral with JAD session provide the context of knowledge sharing and elicitation. Knowledge and information resulted from each loop brings about new knowledge. The combination of software spiral and knowledge spiral what so-called in this research "the double spiral model" is shown in the previous Figure 3.1.

3.6 KMS Evaluation

System evaluation is the essential step for software engineering process. It is the method to guarantee that the developed system matches the specification and user requirements. Moreover, any risks that are found early at the inner loop of the double spiral will be manageable. In the software engineering approach, the evaluation concept can be measured by users' satisfaction. Functional test to the system function and operational test to business scenario can be done for this purpose. This is to verify that the developed system can support all individual requirements for every JAD session.

However, for the business scenario using double spiral model, it has to deal with rapid changes in both technologies and new knowledge requirement. Verification and validation approach may not practical with this case. The business suggestions to further develop the next incremental revision are essential. For example, web based tools for social network may be changed next year of business events may focus on different domain knowledge. Therefore, the suggestion system for the next KMS model must concern and response to the emerging technology and new knowledge.