Chapter II

# Knowledge Management Context

## II.1. Introduction

The success of the industry cluster in the developing phase relies heavily on the degree of knowledge sharing and collaboration among the members of the cluster. These two factors create *"fresh knowledge"* which is the essential ingredient for creating competitiveness of the cluster. For this reason, knowledge management is the influential mechanism to achieve this. Thus, the first part of this chapter will clarify knowledge management, taxonomy of knowledge and knowledge management processes in the industry cluster domain. As we declared that the KMS is a key for improving knowledge sharing and collaboration within the cluster. It is a set of information technologies that are custom designed, configured or developed to support the knowledge activities in the organization. In the second part of this chapter, the studies about knowledge management system, its architecture and the information technology usually implemented in knowledge management projects will be reviewed and compared.

Finally, the last part of this chapter aims to close the gap between knowledge management processes and the knowledge management system with knowledge engineering methodology. Knowledge engineering is always used for designing, developing and maintaining the knowledge-based system in the knowledge management projects. The content in this chapter will mainly focus on selecting the appropriate knowledge engineering methodology for the industry cluster context. Suitable methodology will be implemented in our study.

## II.2. Knowledge Management

In the past, the three production factors (Land, Labor and Capital) were abundant, accessible and were considered as the reasons for economic advantage. Knowledge did not get much attention [Young 03]. Nowadays, the knowledge-based economy era is affected by the increasing use of information technologies. Thus, previous production factors are currently no longer enough to sustain a firm's competitive advantage; knowledge is being called on to play a key role [Romer 86]. The knowledge-based economy is based on the production, distribution and use of available knowledge and information [Porter 90] to gain more competitive advantages over others. To this purpose, Knowledge Management (KM) is the discipline that helps spread knowledge of individuals or groups across organizations in ways that directly affect performance.

However, the discipline of KM has changed very fast during last decade. We can separate KM practice into two generations. First-generation KM sought to enhance the integration of existing organizational knowledge through strategies such as knowledge capture and sharing. Second-generation KM strives to improve knowledge integration, too, but it also seeks to improve knowledge production. To illustrate this concept, the study of Dave [Dave 07] has distinguished two generations of knowledge management in term of value proposition, strategy, content format and model as shown in table II.1.

| | **1st Generation KM<br>1995 – 2005** | **2nd Generation KM<br>since 2005** |
|---|---|---|
| **KM Value Propositions:** | Reduce cost, Improve customer relationships, Accelerate employee learning, Improve technology ROI, Increase employee retention | Find and contact with people more effectively,<br>Tap the wisdom of crowds<br>Facilitate virtual collaboration,<br>Improve the context and understandability of information,<br>Improve knowledge worker effectiveness |
| **KM Strategy:** | Users contribute best practices to large central repositories for re-use to reduce costs | Stories and conversation automatically canvassed from shared personal repositories for learning and discovery |
| **KM Content Format:** | Mostly text, organized by subject (taxonomy) | Graphic and multimedia, organized by application (ontology) |
| **KM Model** | Acquire, store, add value, disseminate | Connect, canvass, synthesize (just in time) |

Table II.1: Generations of knowledge management [Dave 07]

From the table above, we can see that the discipline of KM these days is more complicated than before. It requires a multi-disciplinary view of knowledge to achieve goals such as management, information technology, organizational learning, etc. In summary, the new generation of knowledge management is managing knowledge in a *collaborative environment*. The following sections will give a clear view of KM in the industry cluster.

**II.2.1. What is Knowledge**

The formal definition of "knowledge" is defined by Webster's dictionary and implies that knowledge extends beyond information. It gives the following description:

> ***Knowledge*-N**. *1.* applies to facts or ideas acquired by study, investigation, observation, or experience *2.* rich in the knowledge of human nature *3.* **Learning** applies to knowledge acquired especially through formal, often advanced, schooling *4.* a book that demonstrates vast learning.

However, *data*, *information* and *knowledge* are three often-encountered words that are close together, seem to have slightly different meanings, yet are often used interchangeably as synonyms, leading to continuing confusion [Schreiber 99]. There are many ways to classify them such as context/domain and characteristic of information. Knowledge very much depends on the context. O*ne person's knowledge can be just another person's information*. For example, company 'A' , expert in ceramic design domain tried to explain their processes, best practices or cautions to company 'B' who is working in ceramic marketing domain. Although the information that company 'A' transferred to company 'B' is essential knowledge, company 'B' cannot transform that knowledge into action. Thus, knowledge from company 'A' is just information for company 'B'. Hence, borderlines between data, information and knowledge are not sharp, because they relate to the context of use.

Another distinguishing aspect of knowledge is the characteristic of information that transferred from actor to actor in the same domain. Schreiber et al. [Schreiber 99] have proposed characteristics and examples of data, information, and knowledge as shown in the following table.

| | Characteristic | Example |
|---|---|---|
| **Data** | Un-interpreted, Raw | …---… |
| **Information** | Meaning attached to data | S O S |
| **Knowledge** | Attach purpose and competence to information, Potential to generate action | Emergency alert → Start rescue operation |

Table II.2: Distinctions between data, information and knowledge [Schreiber 99]

- **Data** are the uninterrupted *signal*s that reach our senses every minute by the zillions, a red, green, or yellow light at an intersection is one example. Computers are full of data: signals consisting of numbers, characters, and other symbols that are blindly and mechanically handled in large quantities.
- **Information** is data equipped with *meaning*. For a car driver, a red traffic light is not just a signal by some colored object, rather, it is interpreted as an indication to stop or go. For example, a red light signal in an interaction is just data in traffic systems, but for drivers it brings information for them to stop their cars.
- **Knowledge** is the whole body of data and information that people bring to bear on practical *use in action*, in order to carry out tasks and create new information. Knowledge adds two distinct aspects: first, a sense of *purpose*, since knowledge is the "intellectual machinery" used to achieve a goal; second, a *generative capability*, because one of the major functions of knowledge is to produce new information.

Simply defined, knowledge is *"actionable information"* [Schreiber 99]. *Actionable* refers to the notion of relevance and being available in the right place at the right time, in the right context, and in the right way so that users can bring it to bear on decisions, unlike information which simply gives us the facts.

According to Nonaka [Nonaka 95], knowledge is *justified belief* (i.e. information) that increases an entity's capacity for effective action, while information is the flow of messages or meaning which may add to knowledge. In that sense, information is raw material for the production of knowledge and information transforms to knowledge in the context of actions. This observation concerning the context dependence of knowledge is found, in different terminology, across different study fields of knowledge [Schreiber 99]. The definitions of knowledge have shown that there is a thin line between knowledge and information. In order to extract the knowledge from the experts in the ceramic cluster, the type of knowledge, location of knowledge and extracting process are necessary. The next section gives details about the taxonomy of knowledge shared in the industry cluster.

### II.2.2. Taxonomy of Knowledge

In order to understand the knowledge exchange model of the industry cluster, the type of exchanged knowledge should be considered. From a review of the literature, knowledge can be taxonomically categorized in different point of views. Polanyi [Polanyi 66] classifies knowledge into two types: tacit and explicit knowledge, by using *complexity of knowledge*. Tacit knowledge tends to have more complexity than explicit knowledge. Accordingly, sharing tacit knowledge is more complicated than explicit knowledge. In the domain of collaboration, knowledge is classified by *how knowledge is created* i.e. individual and social knowledge [Nonaka 94]. Individual knowledge is created by individuals; this type of knowledge is a personal expertise which can be developed from learning-by-doing. Social knowledge is created by collective actions of a group of people. Another view point of knowledge categorization is *how knowledge is used*. The taxonomy of these knowledge types i.e. know-who, know-what, know-how, know-where, know-when, and know-with. The definitions and examples of the taxonomy are summarized in the table II.3.

| **Approach** | **Knowledge types** | **Definition** | **Examples** |
|---|---|---|---|
| Complexity of Knowledge [Polanyi 66] | Tacit | Knowledge is rooted in actions, experience, and involvement is specific context | Unstructured knowledge such as surgery skill. |
| | Explicit | Articulated, generalized knowledge | Codified knowledge such as diagnostic skill |
| Creation of Knowledge [Nonaka 94] | Individual | Created by and inherent in the individual | Individual's belief on cause and effect such as crafting skill |
| | Social | Created by and inherent in collective actions of a group | Norm for inter-group communication such as best practice |

| Approach | Knowledge types | Definition | Examples |
|---|---|---|---|
| Use of Knowledge [Lundvall 94] | Networking | Know-Who | How can I "know who knows"? e.g. yellow pages |
| | Declarative | Know-What | What method is appropriate for shipping products? |
| | Procedural | Know-How | How to solve production problem? |
| | Conditional | Know-When | When the seminar will take place? |
| | Locational | Know-Where | Where is the conference about product design? |
| | Relational | Know-With | Understanding how the problem relates to another problem. |
| | Causal | Know-Why | Why does this problem occur? |

Table II.3: Examples of the knowledge category

Polanyi first described two types of knowledge i.e. tacit and explicit knowledge in 1966 [Polanyi 66]. *Tacit knowledge* is knowledge that is impossible to articulate (e.g. how to ride a bicycle). *Explicit knowledge*, on the other hand, is knowledge that can be articulated (e.g. a bicycle has two wheels). Tacit knowledge is often thought of as knowledge of how to do things (i.e. procedural knowledge). Then, Nonaka and Takeuchi [Nonaka 95] argued that “the key of knowledge creation lies in the mobilization conversion of tacit knowledge”. They give another definition for tacit and explicit knowledge as follows. *Tacit knowledge* is comprehension within an expert's mind and which cannot be directly expressed by data or knowledge representations. It is commonly referred to as unstructured knowledge (e.g. knowledge embedded in the human mind through experience and jobs). *Explicit knowledge* is knowledge which can be directly expressed by knowledge representations (e.g. knowledge that is codified and digitized in books, documents, reports, memos, etc.) which is known as structured knowledge. Nonaka stated that converting explicit knowledge to tacit knowledge is closely related to ‘learning by doing’. This process was defined in the internalization process in Nonaka’s SECI model [Nonaka 94] as shown in Annex B. The *knowledge spiral* is a model for creating and transferring knowledge in the organization. The spiral processes aim at creating competitiveness of organization from the fresh knowledge of members. As in the industry cluster, competitiveness was developed from the collaboration of members in core and supporting clusters. The new knowledge was jointly created from cluster activities such as marketing, product development, training, etc.

(a) Use of Knowledge

The knowledge can be categorized into 7 types of knowledge according to how the knowledge is used [Lundvall 94]. These types of knowledge are often used for understanding characteristics of exchanged knowledge in each activity in the organization.

**Know-Who** is the networking knowledge. It has been claimed to be the most necessary knowledge in the organization due to limits of individual knowledge, one person is an expert only in their domain. Thus, the Chief Knowledge Officer (CKO) needs this knowledge to find the right person to participate in the task.

**Know-What** is the basic sense of knowing. This is especially true in complex situations in where experience is required. For example, the expert instinctively knows what "firing" is in the context of ceramic production

**Know-How** is the knowledge of how to get things done. Some of this knowledge is made explicit in organization procedures, i.e. codified knowledge. However, in practice, knowledge is still in tacit form. Acquiring know-how depends on skill and practice that takes time to develop and refine. This type of knowledge is always transferred within a particular community/domain.

**Know-When** is the knowledge involved with time domain. Since time is always a condition of every task, know-when is required by experts to acquire opportunity or solve problems. In our study, Know-When is mostly transferred when a new opportunity is offered to the members of the cluster, such as when should we contact a government agency for a tax reduction.

**Know-Where** is a type of knowledge which concerns strategic location. However, the communications technology has changed the nature of geography in the business world such as e-commerce. The strategic location is still a key success factor of organizations, especially in the logistic domain. A company gains the competitive edge over another from knowing where the strategic location is. However, this knowledge is shared in the industry cluster in terms of indicating the location of the opportunity, such as where the ceramic trade fair will take place this year.

**Know-With** is the knowledge that describes how things relate to other things. This knowledge helps experts reuse their knowledge with similar problems. This knowledge is represented in the form of *ontology*. Understanding the relationship between two things (objects) helps expert to reuse their knowledge. For example, if an expert knows that ceramic clay type A *has property* B it will *create a problem* crack in the finished product. Thus, experts can reuse their knowledge by presuming that ceramic clay type Z, which has the same property as B, will create the same problem.

**Know-Why** is a backward reasoning of the knowledge. Mostly, this type of knowledge is used to discover the cause of the problem. Many times, the ontology is used for reasoning the cause of a problem. If the expert found a problem, such as a crack in a finished product, he is able deduce that this may be caused by a property of the clay.

In this study, we will adopt this taxonomy of knowledge in order to represent the knowledge exchanging model in the industry cluster. This issue will be referred to in the collaboration model in our proposed methodology in Chapter 3. Another factor that separates knowledge from information is place of knowledge (called domain of knowledge). In the KM practice, domain knowledge can be broken down into small communities of practices. The concept of this issue will be explained in the next section.



### II.2.3. Community of Practice (CoP)

Community of Practice (CoP) is a small group of people who have worked together over a period of time. People in CoP can perform the same job or collaborate on a shared task or work together on a product [Lesser 00]. What holds them together is a common sense of purpose and a real need to know what each other knows (knowledge sharing). CoP is often used as a learning tool in organizations to create a collaborative culture and provide a knowledge sharing environment. Thus, CoP has become a fundamental of many knowledge management systems.

The main objective of the CoP is facilitating a group of people to share their experience over a particular subject of common interest. This shared experience helps each person to solve day to day problems and update themselves with *fresh knowledge* in the area of their interest. In a CoP, there are three elements present: domain, community and practice. The study of the DTI [DTI 05] insisted that "*cluster networks need to be more than simply opportunities to meet. Networks will ideally form "Communities of Practice" (CoP), with many such networks present in each cluster, associated with different interests. What causes one company or interest to join a cluster will not be the same for everyone and their needs are likely to shift in time. It is likely that networks will continuously form and reform as membership and needs change*".

- ***Domain*** is the area or the subject of interest which binds all the members together. This can be our profession, or any other area of our interest. A domain keeps the point of discussion focused. The members of the ceramic cluster are in the same domain - the ceramic business. As we discussed about the definition of knowledge, one person's knowledge can be just information to another. The common interest stimulates members to share useful knowledge with each other.
- ***Community*** concerns the interaction, trust, relationship, and structure of community. Forming a community requires appropriate frequency of the interaction. A one time interaction could not create community. Trust and the good relationship of members will sustain the community. The structures of industry clusters vary due to the environment of collaboration. The formal interaction, such as cluster meetings, was held once a month. Thanks to internet technology, the informal interaction such as e-mail, chat, and web board can be established between formal interactions. Trust and relationship are concerned in our study, with the special relationship as "*coopetition*" (cooperation and competition in the same environment) making a cluster unique. In this study, we analyze the cluster's relationship characteristics in order to propose a suitable knowledge management system.

- ***Practice*** binds the members with some benefits of collaboration. A ceramic producer and a financial institution can not join the same community of ceramic manufacturing. They must be active in their area to get benefit out of the interaction. This implies that a single domain comprises many practices. However, the practice depends on the common interest of cluster members. The practice also guides experts to share the specific knowledge in the right places, which makes knowledge retrieval easy. An example of CoPs in a ceramic cluster domain is illustrated in figure II.1.

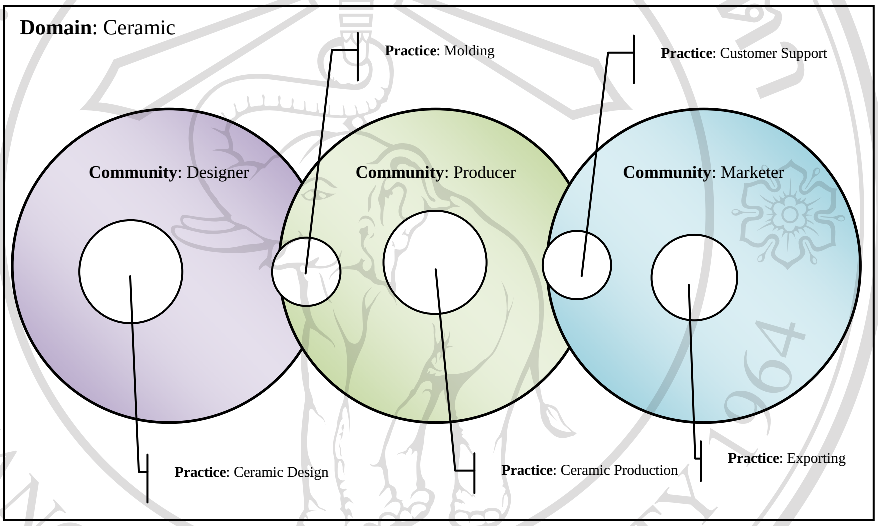


Figure II.1: An example of Community of Practices in a ceramic cluster

The development of CoP could help companies to share ideas, trade or innovate with new ideas. They can also operate across the clusters in such areas as training or workshops. Communities of interest are likely to be a feature of clusters of the future, and indeed many industries are taking steps to encourage this process through the creation of virtual enterprise networks or centers of industrial collaboration [DTI 05]. Organization culture and its knowledge management system play an important role in promoting community interaction. These will be discussed further in our methodology.



### II.2.4. Knowledge Management Processes

In order to transform knowledge into a valuable organizational asset, knowledge, experience and expertise must be formalized, distributed, shared, and applied. Knowledge management is considered a key part of the strategy to use expertise to create a sustainable competitive advantage in today's business environment [Beckman 98]. These processes are variously defined in the different study as shown in table II.4.

| DiBella and Nevis,1998 | Holzner and Marx, 1979 | Ruggles, 1997 | O'Dell, 1996 |
|---|---|---|---|
| 1. Acquire<br>2. Disseminate<br>3. Utilize | 1. Creation<br>2. Storage/Retrieval<br>3. Transfer<br>4. Application | 1. Generation<br>Creation<br>Acquisition<br>Synthesis<br>Fusion<br>Adaptation<br>2. Codification<br>Capture<br>Representation<br>3. Transfer | 1. Identify<br>2. Collect<br>3. Adapt<br>4. Organize<br>5. Apply<br>6. Share<br>7. Create |

Table II.4: Comparing knowledge management processes

However, the simple idea of each model is (1) creating, (2) representing, (3) sharing and (4) utilizing the knowledge identically. These processes are considered as the major activities for improving the competitiveness of organization in terms of knowledge. The details of each process will be described in the following sections.

(a) Knowledge Creation

Knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge [Pentland 95]. Creating (or acquisition) refers to the activity of identifying knowledge in the organization's environment and transforming it into a representation that can be internalized, and/or used within an organization [Holsapple 99]. Nonaka has proposed the knowledge creation model (called SECI model as shown in figure II.2) to explain how the knowledge is created in the organization [Nonaka 95].

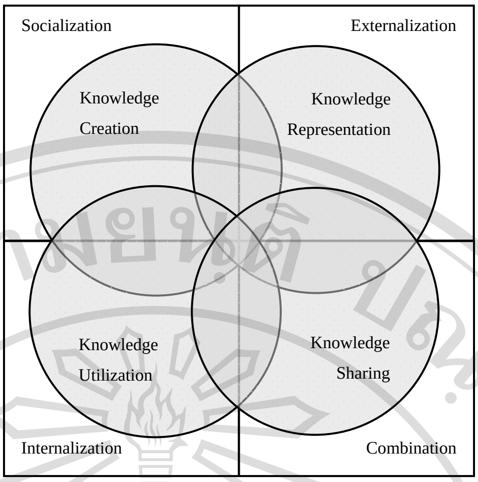


Figure II.2: Knowledge processes and SECI Model [Nonaka 95]

The model implies that the knowledge is created when converted from tacit knowledge into explicit knowledge and combined with explicit knowledge from others. Then, the new tacit knowledge is obtained when it was internalized by a learning process. The new knowledge is created in the *socialization* mode in the model. Knowledge creation also refers to ability to combine new knowledge with experience in order to create new tacit knowledge. This process mostly occurred inside human. There is no effective information technology that supports creating tacit knowledge in humans directly, but the collaborative tools such as telephone, live chat, discussion board, etc. could support knowledge workers to create new knowledge as well.

(b) Knowledge Representation

Knowledge representation may be called by different names such as organizing, customizing or codifying knowledge [Schreiber 99]. The objective of this process is representing the knowledge to suit the knowledge selection. Comparing this process with SECI model, knowledge representation is transforming tacit knowledge into explicit (codified) knowledge which is equivalent to the *externalization* mode in the SECI model. In the past, representing the knowledge was done by writing, drawing or coding the knowledge into a codified format (e.g. procedure). Nowadays, the emergence of multimedia and information technology means that knowledge can be represented in various forms and formats such as sound, picture, video, concept map, 3-D model, database, etc. These technologies make it possible for experts to articulate their tacit knowledge into explicit knowledge, which was nearly impossible in the past.

(c) Knowledge Sharing

Knowledge sharing (known as knowledge transferring) is disseminating personal knowledge in the explicit form over the organization through a specific medium. The sharing of knowledge constitutes a major challenge in the field of knowledge management, without this process the new knowledge could not be created. Thus, most studies give an important role to this process. Knowledge sharing could be mapped with the *combination* mode in SECI model. This mode aims to disseminate the explicit knowledge within the community of practice. In order to achieve this, internet technology is the key that accelerates knowledge sharing today. We can see a number of best practices about knowledge sharing in many specific communities over the internet.

(d) Knowledge Utilization

Knowledge utilization is integrating the knowledge into the organization. In the knowledge engineering domain, this process refers to providing the right knowledge to the right person at the right time, right place and right format. Thus, knowledge storage and retrieval are considered as a key technology that supports knowledge workers to complete their task. This process supports the internalization mode in SECI model. It helps knowledge workers to internalize the explicit knowledge and transform to tacit knowledge when needed. Knowledge retrieval is extraction of knowledge from identified knowledge resources (i.e. document, computer system, an employee) [Holsapple 99]. This technique is often related to the representation mode of the knowledge. Then, there are a lot of interdependencies between representation mode and retrieval mode.

One of the main objectives of the present work is to improve the knowledge processes in the industry cluster. Hence, the knowledge management system which is a set of information technologies is the mechanism to support this cluster. The details of knowledge management system will be described in the next part.

**II.3. Knowledge Management System**

Knowledge management is the discipline that helps spread knowledge of individuals or groups across organizations in ways that directly affect performance. It envisions getting the right information within the right context to the right person at the right time for the right business purpose [Klung 01]. Accordingly, Knowledge Management System (KMS) concerns a set of Information Systems (IS) that are applied to manage organizational knowledge by supporting and enhancing the processes of knowledge creation, transfer, storage/retrieval, and representation. To achieve this, the design of information systems should be rooted in, and guided by, an understanding of the nature and characteristic of organizational knowledge.

Alavi and Leidner [Alavi 01] defined a KMS as *"IT (Information Technology)-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application"*. Maier (2002) expanded on the IT concept for the KMS by calling it an ICT (Information and Communication Technology) system that supported the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application.

Technology cannot provide a perfect substitute for face-to-face contact, which is crucial for building a culture of knowledge sharing [Robert 00]. Neither can it replace human social interaction in affording rich interactivity among individuals necessary for knowledge creation [Fahey 98]. Nonetheless, technology is able to overcome the barriers of time and space that would otherwise be limiting factors in KM activities. As we mentioned the difficulty of knowledge sharing in the industry cluster in the last chapter, the members of the cluster feel uneasy to share their knowledge in face-to-face conditions due to part of their relationship being competitive. In this case, sharing knowledge via KMS seems to be an appropriate solution for the industry cluster context. In addition, KMS also serves as a repository in which knowledge can be reliably stored and efficiently retrieved. The key is to understand how technology is most appropriately deployed and aligned to the knowledge activities in the organization.

### II.3.1. Human roles in the KMS development

It is important to identify the roles that humans play in the knowledge management processes. From the study of Schreiber et al. [Schreiber 99], six roles are considered for developing the KMS for the organization. However, the number of roles could be less in smaller projects, and other roles such as project manager could be added to the processes in larger project. The correlation and responsibility of each role are illustrated in figure II.3 and briefly explained.

**Knowledge manager** addresses the knowledge needs of the enterprise, researching to understand what knowledge is needed to make decisions and enable actions, and establishes the knowledge management policies at enterprise level. In a simple project, the knowledge manager could act as project manager in order to manage and facilitate knowledge engineer and knowledge system developer.

**Knowledge engineer** (or knowledge analyst) works on such areas as data and information representation, repository storage and retrieval, workflow management, information technologies, etc. The roles of knowledge engineers would most likely be researching the technologies needed to meet the enterprise's knowledge management requirements, establishing the processes by which knowledge requests are examined, information assembled, and knowledge returned to the inquirer. The role of knowledge manager and knowledge engineer are often used alternately, which leads to misunderstanding. The main difference seems to be that the knowledge manager establishes the direction the process should take, whereas the knowledge engineer develops the means to accomplish that direction.

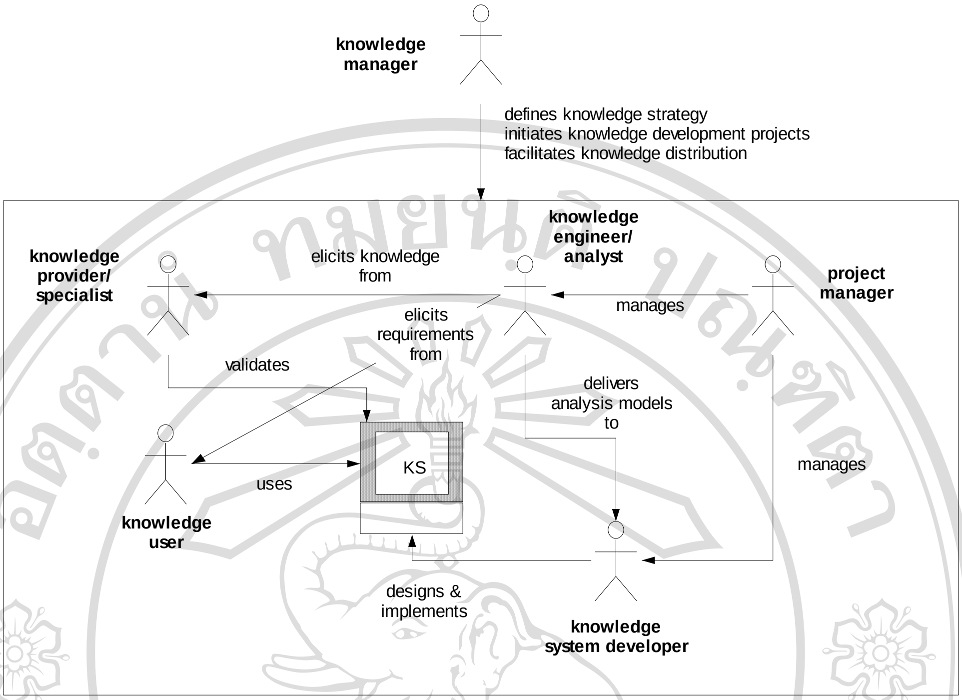


Figure II.3: Human roles in knowledge engineering [Schreiber 99]

**Knowledge provider** (or expert) is the owner of the knowledge who plays an important role in the process. One important problem for a knowledge engineer is to find the 'real' expert [Schreiber 99]. Fake experts are very harmful for the knowledge management project. The two major responsibilities of the experts in the processes are providing useful knowledge to the knowledge engineer and validating knowledge in the knowledge system.

**Knowledge user** (or knowledge worker) makes use, directly or indirectly, of a knowledge system. Involving knowledge users from the beginning is even more important than in regular software engineering projects [Schreiber 99]. The two major responsibilities of knowledge users in the processes are providing requirements to knowledge engineers and use of knowledge system for making decisions to complete their knowledge tasks.

**Knowledge system developer** is actually a software designer. In a small project with fewer complexes in software implementation, this process was often done by the knowledge engineer. The responsibilities of a knowledge system developer are acquiring system specifications from the knowledge engineer, and designing and implementing the knowledge system.

### II.3.2. Knowledge Management System Architecture

Developing a KMS is a complex task and requires a careful planning before selecting the tools for supporting the knowledge processes. The designed system architecture should suit the organizational culture and business needs. KMS can be as simple as a file folder until a complex business intelligence system which uses an advanced data visualization and artificial intelligence. Thus, we have studied several KMS architectures which aim to support knowledge management processes and collaboration in the organization. We found that even if there are differences between architectures in term of functions and services, the major components of architecture are comparable. The general KMS architecture is proposed by Tiwana [Tiwana 02]. He pointed out that the KMS should comprise four major components: repository, collaborative platform, network, and culture.

1 *Repository* holds explicated formal and informal knowledge, such as declarative knowledge, procedural knowledge, causal knowledge, and context. This component acts as the core of KMS which aims to store and retrieve knowledge for future use.

2 *Collaborative platform* supports distributed work and incorporates pointers, skills databases, expert locators, and informal communications channels.

3 *Network* means both physical and social networks that support communication and conversation. Physical network is a ‘hard’ network such as intranet, shared space, and back bone. Social network is a ‘soft’ network such as Communities of Practice (CoP), associations, and working groups.

4 *Culture* is the enabler to encourage sharing and use of the KMS. Research has revealed that the greatest difficulty in KM is ‘‘changing people’s behavior,’’ and the current biggest impediment to knowledge transfer is ‘‘culture’’.

These four components are considered as the basis elements for each knowledge management system. However, other tools could be integrated to enhance the quality of services of the system. Tiwana also proposed seven-layer KMS architecture [Tiwana 02] which is the integration of these four components and their supportive information technologies.

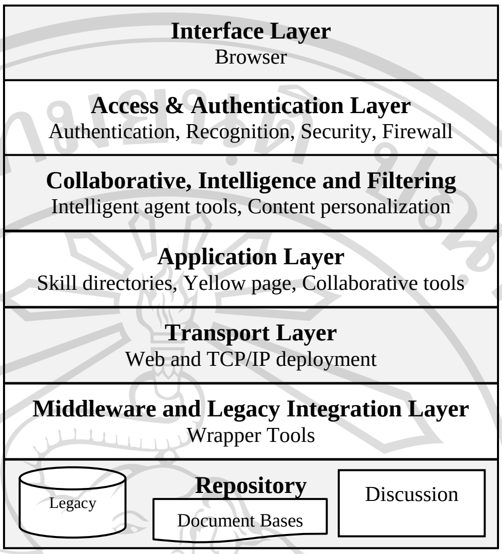


Figure II.4: Seven layers KMS architecture [Tiwana 02]

Actually, seven layer KMS architecture is just a reflection of OSI model (Open Systems Interconnection basic reference model). This model tries to represent the functions and tools of KMS in terms of layer that the knowledge passed though. This architecture might suit with complex systems which require network and data manipulation.

Chua [Chua 04] has proposed a simple architecture called three-tiered KMS architecture which is composed of three services i.e. *infrastructure services*, *knowledge services*, and *presentation services*. These services aim at supporting knowledge processes and communication in the organization. This system emphasizes technologies that help creating, sharing, and storing knowledge. Figure II.5 illustrated Chua's three-tiered KMS architecture

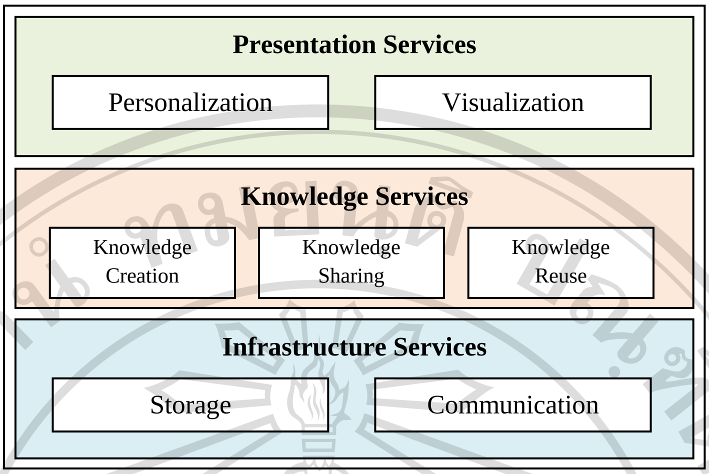


Figure II.5: The three-tiered architecture [Chua 04]

- The first tier in this model comprises the infrastructure services which focus on storage and communication technology. Storage technology is a part of a repository in the general model, and is typically the basis for supporting KM processes, particularly knowledge creation and knowledge reuse. The communication technology makes possible for the KMS to support knowledge transferring activity among the users.
- The second tier is the knowledge services which focus on technologies for creating, sharing, and reusing of knowledge in the system. The technology for knowledge creation helps users to convert their tacit knowledge in to codified (explicit) knowledge. Knowledge sharing technology refers to the flow of knowledge from one part of the organization to other parts. The knowledge reuse helps users to retrieve required knowledge from the system when needed.
- The third tier is presentation services which mainly focus on displaying the suitable information for users to support their decision-making. Technologies that provide presentation services are primarily concerned with enhancing the interface between the user and the information/knowledge sources. This part is related to the culture of knowledge usage of the organization by visualizing and personalizing all services in the KMS to suit the organizational culture. However, to design these services, the organizational analysis is required.

One of the technical perspectives of KMS architecture was proposed by Meso and Smith [Meso 00], as shown in figure II.6, which consists of three components: technology, function and knowledge. This model involves the processes for acquiring or collecting, organizing, disseminating or sharing knowledge among people in an institution.

Meso and Smith's model relies on four functions of knowledge processes: using, finding, creating, and packaging knowledge. These four functions are supported by various information technologies (such as messaging, web browsing, data mining, intelligent agents, etc.) that aim to facilitate the knowledge process. The objective of this model is to enhance each type of knowledge in different taxonomy i.e. know-how, know-what, know-why, self-motivated creativity, personal tacit, cultural tacit, organizational tacit, and regulatory assets. Alavi [Alavi 99] supports this concept by specifying that *KMS refer to a class of information system applied to managing organizational knowledge* and support knowledge processes.

The reviews show that there is no single solution for neither designing, nor best practice of the KMS architecture. Each system is designed to fit with the different culture, activity, strategy, and objective of each organization.

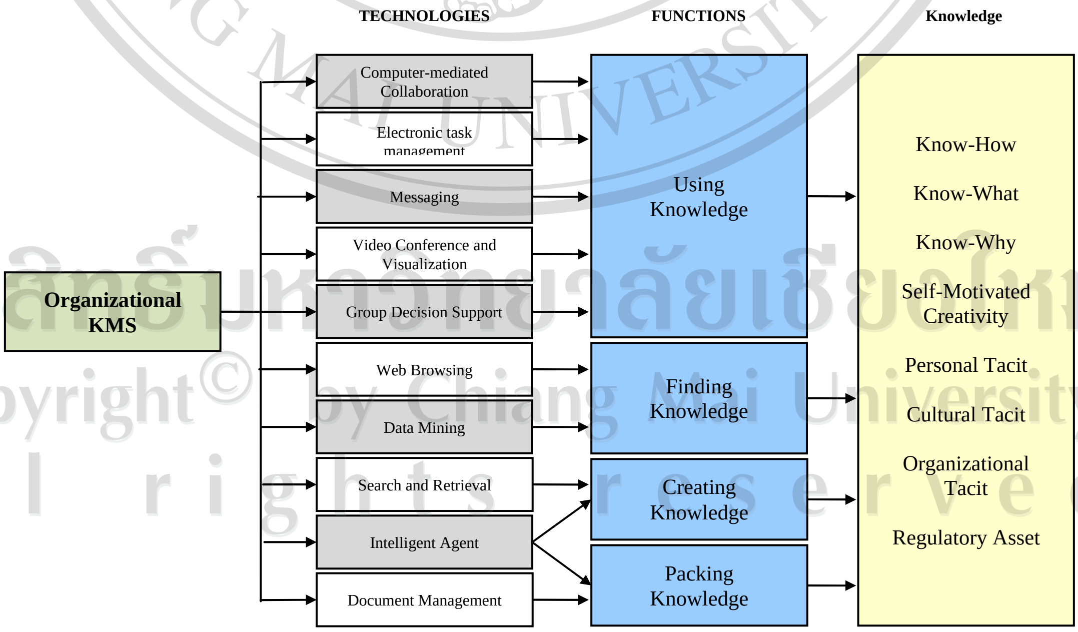


Figure II.6: A technical perspective of KMS architecture [Meso 00]

They also showed that KMS is composed of three common applications: (1) the coding and sharing of best practices, (2) the creation of corporate knowledge directories, and (3) the creation of knowledge networks The next section will present a list of information technology generally used in KM projects and compare their function with the knowledge processes.

### II.3.3. Technology in Knowledge Management

The most valuable role of technology in KM is broadening the reach and enhancing the speed of knowledge transference. Technology plays three key roles in KM domain. Firstly, it facilitates communication among the experts and knowledge users in the organization. Secondly, it provides the infrastructure for storing codified and explicated knowledge. Lastly, it assists with mapping dispersed bits and pieces of tacit and explicit knowledge to establish and maintain intricate interdependencies among them [Tiwana 03]. Due to the fast growth of the information technologies during recent years, KMS became the major tool to manage knowledge in the organizations. However, the critical aspect of building a KMS is determining the best combination of available tools and integrating them into a coherent architecture. Considering the overview of available technologies, and the activities they support, can be very useful in the KM implementation processes. From our literature review, many different technologies are proposed to support knowledge management activities for different purposes. Table II.5 shows a list of the information technologies which are generally used to support the KM processes.

| Technology | Purpose | Create | Represent | Transfer | Utilize |
|---|---|---|---|---|---|
| Data Mining [Becker 99] | Identifying and extracting from any knowledge sources data patterns that are interesting and meaningful regarding a particular knowledge issue. | X | | | X |
| Collaborative System [Tiwana 03] | Aim at improving quality of communication between users in the community. It is also used as a tool to transfer information/knowledge. | X | | X | |
| Expert System, Rule Based System [Huntington 99] | To capture a portion of the expert's decision-making knowledge, codify it in a way that preserves it, and that make it processed by an inference engine that can use "backward chaining" or "forward chaining | | X | | X |
| Case Based Reasoning [Tiwana 03] | To use capabilities of memorization and similarities retrieval processes to face new problems by comparing them to old archived . | | X | | X |

| Technology | Purpose | Create | Represent | Transfer | Utilize |
|---|---|---|---|---|---|
| Database [Tiwana 03] | To support the management of persistent data by providing facilities to create, remove, update and access to pieces of these data. | | | | X |
| Data Warehouse [Sena 99] | To enable systematic archiving of operational data to enable potential future analysis. | | | | X |
| Semantic Network [Becker 99] | To provide a conceptualization of a given area of interest, by defining consistent categorization of all the concepts identified into this area and by linking them through meaningful relationships. | | X | | |
| Ontology [Gruber 93] | To provide complete and meaningful representation of all the required concepts pertaining to a given area of interest. | | X | | |
| Ontology oriented retrieval [Dieng 00] | To improve the relevancy of expected results of a document retrieval attempt by providing symmetrical conventions addressing both annotation definition and query formulation. These conventions are supported by the ontology. | | | | X |
| Wiki Web [Nastase 08] | To make possible collaborative content management which allow user to create, share and modify the content collectively. | | | X | |
| Search Engine [Kim 07] | To store and to classify web pages according to their content and level of interest. | | | | X |
| Electronic Document Management Systems [Dieng 00] | Providing facilities to support complete document management from the creation to the archiving. | | | | X |
| Workflow system management [Azarian 99] | Providing supports for monitoring and execution of a part of all the business processes involved in an enterprise organization. | | | | X |
| Groupware [Coleman 99] | Supporting the efforts of teams and other paradigms which require people to work together, even though they may not actually be together, in either time or space. Groupware maximizes human interaction while minimizing technology interference. | | | | X |
| Multi agent system [Baek 97] | To distribute the Knowledge management system architecture through different proactive components able to collaborate and to achieve some identified task on behalf of their human users. | | | | X |
| Push/Pull Technology [Tiwana 03] | Push technology distribution and deliver knowledge to their audience after filtering it through highly customized filter. Requires a user to actively seek information when they need it. This system does not distract user by unwanted updates but requires user initiative. | | | X | X |
| Discussion Board [Yang 05] | Help users to request information and respond to the issue. It could be used as a tool for gathering solutions from different points of view. | X | | | |
| Topic (Concept) Map [Wang 07] | Aim at representing the concepts in term of semantic maps. It is often used as a tool for organizing personal and organization knowledge. | | X | | |
| Knowledge Card [Buzon 03] | Is integrating the concept of topic map and wiki web together to make it possible for users to represent and share their knowledge in the organization. | | X | X | |

Table II.5: List of IT generally used in KM projects

The table shows the examples of technologies that were used in many KM projects. Although many KMS initiatives are relying on IT as an important enabler, designing greatly relies on the non-technical side. Organizational culture is a key factor in selecting tools and technologies to support the KMS application. Thus, the organizational analysis is called to play an important role in designing the KMS. The details of the analysis will be discussed in the next section.

### II.3.4. Designing a Knowledge Management System

In recent years the term knowledge management has been used to describe the efforts of organizations to capture, store, represent and share knowledge. It helps an organization to gain competitive advantage and effective work through sharing and re-use of knowledge in an organization. Most current knowledge management activities rely on database and web-based technology, document management system, artificial intelligence, etc. However, few organizations have a systematic process for capturing knowledge, as distinct from data [Preece 00]. Thus, knowledge engineering, which is an aspect of systems engineering, was applied to deal with knowledge management in an organization.

Knowledge management practices significantly under utilize knowledge engineering technologies [Preece 00] as it was viewed as being equivalent to transferring knowledge from an expert into a knowledge base. Knowledge engineering has often been concerned only with knowledge acquisition processes (to capture structured knowledge systematically), and knowledge representation processes (to store the knowledge, preserve important relationships), which often failed [Studer 03]. Actually, the role of knowledge engineering in knowledge management is supporting the knowledge engineer to deal with information in each stage of knowledge management. The processes of knowledge engineering can be described as follows:

- *Analyzing* the role of knowledge skills and expertise in an organization.
- *Understanding* how knowledge supports the organization in meeting its objectives.
- *Identifying* knowledge sources, knowledge flows, knowledge bottlenecks and where the organization is vulnerable to knowledge attrition through staff losses.

- *Determining* the scope of improving performance through knowledge acquisition, knowledge utilization, knowledge communication and knowledge representation.
- *Implementing* the systems in the organization necessary to achieve the improved performance and business effectiveness.

These processes help knowledge engineer to understand the culture of knowledge usage and characteristics of the knowledge in the organization, which are crucial elements for designing the KMS for the organization. Moreover, the KM project often needs change management to enhance the competitiveness of knowledge workers in the organization. Knowledge engineering could provide the consensus between the members of an organization in the KM project. Hence, in this study, knowledge engineering methodology was adopted for designing the KMS for the industry cluster. The models and examples of knowledge engineering methodology will be discussed in the following part.

**II.4. Knowledge Engineering**

Knowledge engineering refers to the designing, developing and maintaining of knowledge-based systems in the knowledge management project. It has a great deal in common with software engineering, and is related to many computer science domains such as artificial intelligence, databases, data mining, expert systems and decision support systems. Knowledge engineering is also related to cognitive science and socio-cognitive engineering, where the knowledge is produced by socio-cognitive aggregates (mainly humans) and is structured according to our understanding of how human reasoning and logic works [Schreiber 99].

Zhao [Zhao, 2005] defined knowledge engineering as *"a process of creating such a semantic system"*. Similar to software development, it includes such tasks as scoping, modeling, integration, deployment and maintenance within the methodology. It emphasizes the formal and methodical process of deductive problem solutions and aims at optimization of solutions. Knowledge modeling is based on guidelines and heuristics tools (e.g card sorting, mind mapping, etc.) in an inductive process of finding appropriate solutions in the context of conflicting interests and requirements.

Knowledge engineering was in a field of artificial intelligence in the past. But since the last decade, knowledge engineers have developed their principles to improve the process of knowledge acquisition [Chua 04]. These principles are used to apply knowledge engineering in many actual environment issues. Firstly, there are different types of knowledge which are defined as “know what” and “know how” [Levy 03] or “explicit” and “tacit” knowledge from Nonaka’s definition [Nonaka 95]. Secondly, there are different type of experts and expertise. Thirdly, there are many ways to represent knowledge and use of knowledge. Finally, there is the use of structured method to relate the difference together to perform knowledge oriented activity [Shadbolt 99]. These created several knowledge engineering techniques to solve different problems in various domains such as diagnosis of bacterial infections, advice on mineral exploration, assessment of electronic circuit designs or financial analysis. In this study, knowledge engineering methodologies (i.e. MOKA, SPEDE, AKEM, and CommonKADS) were reviewed and compared in order to propose a methodology for applying a selected technique in the industry cluster development domain. The next section, knowledge-based engineering lifecycle (which is a general model of knowledge engineering), will be analyzed for benchmarking and selecting a suitable methodology.

**II.4.1. Knowledge-Based Engineering Lifecycle**

Knowledge engineering differs from conventional software engineering mainly at the early stages of the lifecycle, when user requirements and functional methods (or knowledge) are being acquired. The tools for implementation, user interface design, testing, maintenance and updating systems may differ, but the principles which govern all software systems are the same. Therefore, although the early stages of knowledge acquisition will involve a knowledge engineer and one or more domain experts, later stages will involve software engineers for implementation/integration. One well known Knowledge-based Engineering (KBE) lifecycle was proposed by Preston [Preston 05]. It focused on six critical phases i.e. identify, justify, capture, formalize, package, and activate as shown in figure II.7.

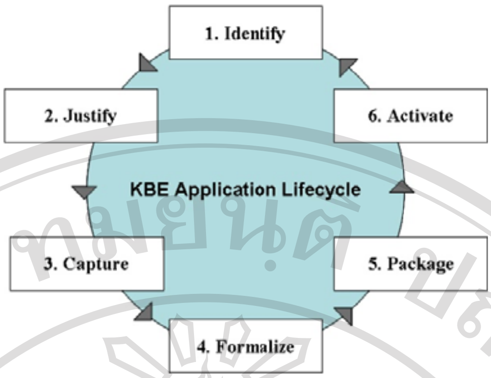


Figure II.7: Knowledge-Based Engineering application lifecycle [Preston 05]

- **Identify** aims at identifying the driving factors of the project. The main activities of this step are studying industrial needs and technical feasibility of the project.
- **Justify** aims to motivate and ensure the relevance of the project. It involves estimation of resource requirements, costs, profit, risk, and development of a project plan.
- **Capture** aims to collect all knowledge related to the application that is to be created. The raw knowledge is sorted and structured into an informal model.
- **Formalize** aims to develop a formal model from captured knowledge. The output from the capture step will be structured into standardized form.
- **Package** refers to implementing the formal model into KBE-platform, i.e. programming. This step mainly focuses on application specification and development.
- **Activate** is the process of populating the finished application. This focuses on dissemination and maintenance.

KBE application lifecycle is usually used for describing the significant processes from the beginning to the end of the project. Thus, most knowledge engineering methodology provides tools that support the KE project lifecycle. In this study, we will use KBE lifecycle as one of the criteria for selecting knowledge engineering methodology. The next section will give a brief review of knowledge engineering methodologies i.e. MOKA, SPEDE, AKEM and CommonKADS, and select a suitable methodology for implementing in this study.

### II.4.2. Knowledge engineering Methodologies

II.4.2.1. MOKA

MOKA stands for *M*ethodology and tools *O*riented to *K*nowledge based engineering *A*pplications. It supports structuring and modeling knowledge about engineering design [Stroke 01]. Moreover, it also provides a standard way of storing knowledge that makes re-use and maintenance of the knowledge assets more feasible. The MOKA methodology focuses on two levels of knowledge representation: *informal model* and *formal model*. These models support the means of recording the structure behind the knowledge, not only things about the product and design process, but also the design rationale as well.

The informal model is assembled from five categories of knowledge types, described on forms known as ICARE forms (*I*llustrations, *C*onstraints, *A*ctivities, *R*ules and *E*ntities). These forms are linked together as shown in figure II.8, and provide a comprehensive and straightforward approach for placing structure upon the raw knowledge. This is done by introducing the knowledge to an appropriate form, depending upon its type, and then defining the links between the individual knowledge elements. The outputs of structure are informal models which can be stored and used for building the formal model.

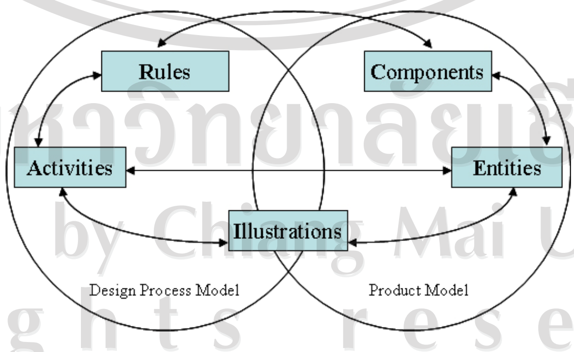


Figure II.8: MOKA ICARE Forms

The formal model is associated with the formalized step. This step is composed of two sub-models i.e. *product model* and *process model* as shown in figure II.9. The product model concerns five views of the product: structure, function, behavior, technology, and representation views. The process model describes the activities and tasks of production. Activities include description, input, output, constraint and method of production. Tasks are types of activities described by a set of activities and their sequence.

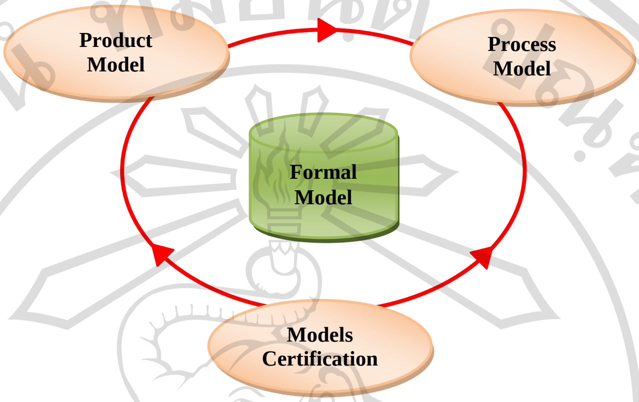


Figure II.9: MOKA formal model

This tool allows the user to create instances of the underlying meta-models. The knowledge stored in the informal model is transferred to the formal model by manual process, assisted by the MOKA tool until the contents of each ICARE form have been dealt with. This methodology is widely used in the aerospace and automotive industries. It is one of the most well known methodologies for knowledge acquisition in the industrial domain. The use of ICARE forms in the informal model, and the product and design process formal models, provides the user with templates specifically suited for the product design process, unlike more generic knowledge acquisition methodologies [Stroke 01]. We realized that MOKA is a concrete methodology which mainly focuses on manufacturing context. However, the methodology did not give much attention to network and culture of organization.



II.4.2.2. SPEDE

SPEDE stand for *S*tructured *P*rocess *E*licitation *D*emonstrations *E*nvironment. SPEDE is funded by both industry (i.e. Rover, Rolls-Royce and Computer Vision) (NB: I think that Rover no longer exists and I don't know the 3$^{rd}$ name) and academia (i.e. the Universities of Leeds, Nottingham and Warwick). It presents a set of widely applicable methods and software tools to assist and guide the business process engineer in the task of Business Process Improvement (BPI); mainly Business Process Reengineering (BPR), but including other improvement approaches. The SPEDE methodology is a combination of principles, techniques and tools taken from knowledge engineering and adapted to knowledge management. It provides an effective means to capture, validate and communicate vital knowledge to provide business benefit [Shadbolt 99].

The concept of the methodology is designing new business process in order to improve the organizational knowledge by using knowledge engineering technique. This was made possible by breaking the activities into generally acknowledged high level BPR/BPI stages and providing a sequence at that level. In addition, it also provides core procedures for capturing the information created by the activities of each stage. The concept of this methodology is called 'Swim Lane' diagram as shown in figure II.10.

These processes help knowledge engineer to understand the context of the organization, such as business processes, people, resources, etc. Each step of the swim lane diagram is assisted by the 'swim lane flowcharts'. They describe the project team's activities for a BPI project sponsor, project manager, project team, and process modeling/simulation specialist [Shadbolt 99].

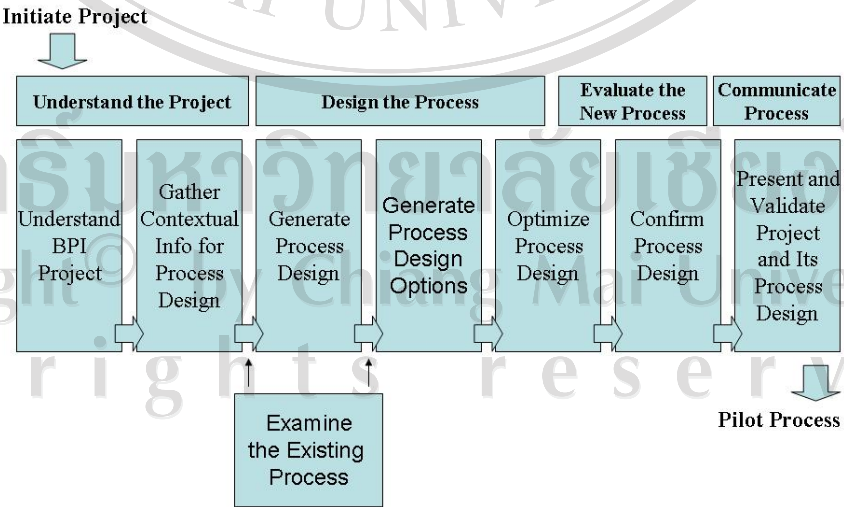


Figure II.10: SPEDE swim lane diagram.

For the knowledge acquisition process, SPEDE provides the Knowledge Requirement Templates (KRTs), which is a part of General Process Ontology (GPO), to facilitate and assist the knowledge elicitation process. KRT provides definition of the required knowledge to make role, agent, organization, and location associated with the 'activities' within a process. The GPO supports knowledge acquisition by enabling the definition of the structure of process knowledge prior to acquisition. Table II.6 shows an example of a KRT.

| **Ontology** | **Relationship** |
|---|---|
| Concept ID: | ... |
| Name: | ... |
| Attributes: | Start Time, Finish Time, Duration |
| Hierarchy Relations: | Has Sub-Activity, Has Parent Activity |
| Sequence Relations: | Ends Before Starts, Starts Before Ends, Starts Before Starts, Ends Before Ends, Starts After Ends, Ends After Starts, Starts After Starts, Ends After Ends, Meets, Contains |
| Resource Relations: | Uses, Produces, Consumes, Releases |
| Data Relations: | Has Data Input, Has Data Output |
| Other Relations: | Is Performed By, Has Location, Has Result |

Table II.6: An example of KRT of activities

In summary, SPEDE is structured methodology which mainly focuses on improving business processes within a company. The knowledge engineering methodology was adapted to enable the integration of process modeling and information modeling to facilitate rapid deployment of reengineered business processes. SPEDE focuses on the context of the organization only in the process aspect. The network and culture of members in the organization is omitted in this methodology. In terms of knowledge processes, this methodology more focuses on knowledge storage and retrieval in order to generate, simulate, and analyze business improvement options, rather than assisting knowledge workers in the organization to achieve their tasks. This methodology is recommended for organizational KM project which focus on the business process of organization.

### II.4.2.3. AKEM

AKEM stands for *A*pplication *K*nowledge *E*ngineering *M*ethodology. It is a knowledge engineering methodology practiced and evolved in FF POIROT project. AKEM is a collection of strategies and heuristics in knowledge capture, representation and application. A key principle of its development is the ease of practice and adaptation with emphasis on low ceremony and agility, considering the features of knowledge engineering and its dynamic contexts [Zhao 05].

AKEM lifecycle model is summarized in figure II.11. It organizes knowledge engineering projects through four phases: inception, elaboration, construction, and transition. Each phase is one or more iteration of 8 activities with different degrees of emphasis and intensity: problem determination, scoping, analysis, development, deployment, test and validation, documentation, and control. It recognizes the importance of knowledge management in knowledge engineering and stresses the facility to trace back to the scope specification and conceptual context in order to recapture or re-examine the previous modeling decisions. It also builds traceability into deliverables in AKEM to enable links among stories, knowledge analysis, ontology, and deployment specification [Zhao 05].

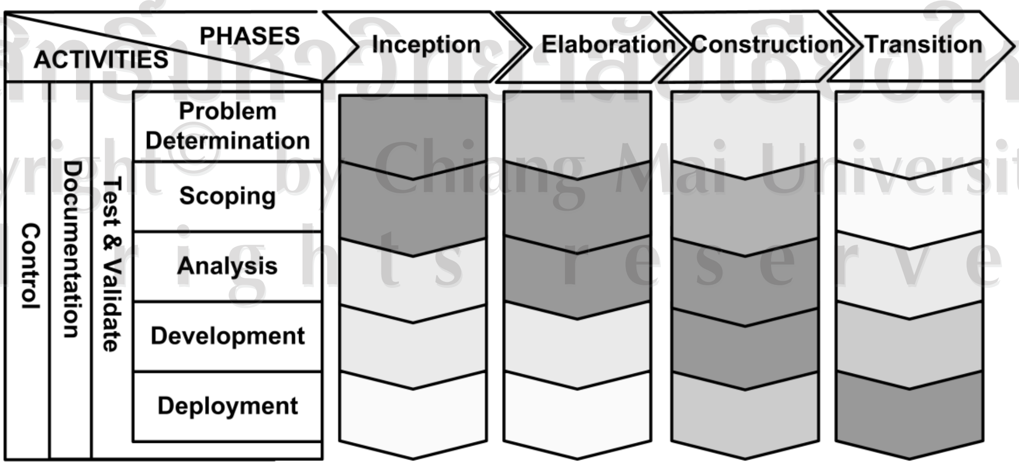


Figure II.11: AKEM lifecycle model

*Problem determination*: is the activity for determining the nature of problems to solve and examine the cost-effectiveness and feasibility of a knowledge-based approach to solutions. The problem space is examined to identify and characterize the problem in the current application and system context.

- *Scoping*: the scoping activity in the domain perspective in AKEM produces two main deliverables: knowledge resources (documents, interview protocols) and stories (knowledge use cases).
- *Analysis activity*: produces the knowledge constituent model and task hierarchy. The knowledge constituent model consists of the knowledge breakdown and the elaboration of each constituent. The knowledge breakdown seeks to modularize knowledge in a hierarchical structure, and the knowledge elaboration provides the description of each constituent in a program specification language to capture the concerned business logic.
- *Deployment*: is modeling the ontology underlying the story and knowledge constituent analysis. The knowledge is not developed only for business logic and rules, but also the underlying meta-knowledge in the form of lexicons (context-term-role relations). The application specific constraints and rules are the special commitments to the lexons. The purpose is to maximize the reusability and versatility of knowledge resources over different applications, time and versions. Ontology is extracted from knowledge resources, such as regulations, requirements specification, abstracted into term-role tuples and organized into an architecture reflecting the knowledge structure of the expert of the subject.
- *Extraction*: is a linguistic work in terms of its input and output. It works on natural language texts selected and generated in knowledge scoping and analysis: knowledge resources, stories and knowledge constituent analysis

In summary, the AKEM methodology is mainly focusing on extracting knowledge from experts and users in the organization for the purpose of developing a suitable knowledge system. The deliverables from each stage of the AKEM's framework are useful to the knowledge engineer to control, plan, and develop the knowledge system project. However, this framework is just a mirror of a software lifecycle development. The key characteristics of this methodology are application-oriented and ontology-based knowledge management system. Ontology modeling processes, i.e. extraction, abstraction, and organization, were exploited for modeling organizational knowledge. However, the method for modeling knowledge for this methodology is still ambiguous. It did not provide the concrete method than linguistic operation, key word highlighting, and paraphrasing. In terms of the knowledge management activities, this methodology concerns all knowledge processes, but mainly focuses only on storage/retrieval and representation. Knowledge creation and transfer are briefly mentioned in the framework. AKEM methodology is suitable for a knowledge management project that relies on ontology and is metadata application-oriented.

II.4.2.4. CommonKADS

CommonKADS stand for *Common K*nowledge *A*cquisition and *D*esign *S*ystem which is a present version of KADS. The method has been developed since 1984 through two major CEC Esprit funded research projects. The methodology aims to support structured knowledge engineering. It indicates the opportunities and bottlenecks in the organizations, distributes and applies their knowledge resources, and so gives tools for corporate knowledge management. It also provides the methods to perform a detailed analysis of knowledge-intensive tasks and processes. CommonKADS supports the development of knowledge systems that support selected parts of the business process [Schreiber 99].

CommonKADS methodology offered a structured approach to break down and structure knowledge engineering process. It provided *CommonKADS model suite* for creating requirements specifications for knowledge system as shown in figure II.12. The method enabled a top-down approach and provided handles for quality control and feasibility assessment.

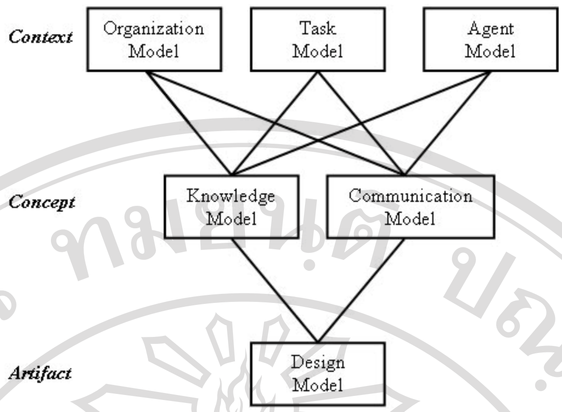


Figure II.12: CommonKADS model suite

- ***Context level*** analyzes the organizational environment and the corresponding critical success factors for a knowledge system.
    - *Organization model* supports the analysis of the major features of an organization, in order to discover problems and opportunities for the knowledge system, establish their feasibility, and assess the impacts on the organization of intended knowledge actions.
    - *Task models* are the relevant subparts of a business process. The task model analyzes the global task layout, its input and outputs, preconditions and performance criteria, as well as needed resources and competences skills.
    - *Agent models are* the agents who are the executors of a task. It describes the characteristics of agents, in particular their competences, authority to act, and constraints in this respect. Furthermore, it lists the communication links between agents in carrying out a task.
- ***Concept level*** yields the conceptual description of problem-solving functions and data that were handled and delivered by a knowledge system.
    - *Knowledge model* explicates in detail the type and structures of the knowledge used in performing a task. It provides an implementation-independent description of the role that different knowledge components play in problem-solving, in a way that is understandable by humans.

  - *Communication model* shows transaction between the agents involved in a conceptual and implementation-independent way, just as with the knowledge model.

- ***Artifact level*** integrates the above levels together in the design model in order to construct the requirements specification for the knowledge system.
  - *Design model* gives the technical system specifications in term of architecture, implementation platforms, software modules, representational constructs, and computational mechanisms needed to implement the functions laid down in the knowledge and communication models.

In terms of knowledge processes, CommonKADS methodology provides knowledge templates for supporting the knowledge modeling process, which constitute predefined reusable knowledge models and which have proven to work in the past. The details of knowledge templates will be described in the next chapter. This methodology concerns all knowledge activities i.e. create, store/retrieve, share, and representation. However, knowledge sharing methods did get much attention in this methodology. The notion of network and organizational culture are analyzed in organizational model in the context level. Although this method did not provide a concrete process for handling a specific task, it is detailed enough to be able to apply in any knowledge intensive task. This methodology is recommended for KM projects that concern the knowledge exchange between agents in intra- and inter-organization.

**II.4.3. Knowledge Engineering Methodology Selection**

In order to select the most suitable methodology to be applied to solve problems in the industry cluster (a macro-economic domain), many well known knowledge engineering methodologies (i.e. MOKA, SPEDE, AKEM, and CommonKADS) were analyzed. Although, these methodologies were successfully implemented in many domains such as product design, CAD/CAM, or cost/time reduction, there is no empirical study that applied knowledge engineering technique to solve industry cluster problem.

Each technique has its own advantages and disadvantages. Moreover, the way for applying the technique in the case study is adaptable to the environment and characteristics of the organization. Thus, in this study, we propose three criteria for comparing and selecting knowledge engineering methodology in the industry cluster, as follows:

1 Coverage of framework for the KM project
2 Provided tools in the methodology
3 Adaptability of methodology to the case study

II.4.3.1. Coverage of framework for the KM project

In order to evaluate knowledge engineering methodology in term of coverage of framework, the KBE application lifecycle represents the significant processes from the beginning till the end of the project, is concerned as a benchmarking tool. Thus, our reviewed KE methodologies will be compared with KBE application lifecycle in purpose of analyzing the completeness of the methodology. The suitable methodology should provide tools that support the KE project from beginning of lifecycle until end of lifecycle. The result of the comparison was shown in table. II7.

| **Methodology** | **KE Project Management** | **Identify** | **Justify** | **Capture** | **Formalize** | **Package** | **Activate** |
|---|---|---|---|---|---|---|---|
| **MOKA** | ICARE Model | - | - | Informal Model | Formal Model | - | - |
| **SPEDE** | Swim Lane Framework | Understand the project | Understand the project | Design the Process | Evaluate the New Process | Communicate Process | - |
| **AKEM** | AKEM Lifecycle Model | Problem Determination | Scoping | Analysis | Deployment | Extraction | - |
| **CommonKADS** | CommonKADS Model Suite | Context Level | Context Level | Concept Level | Concept Level | Artifact Level | - |

Table II.7: Comparing KE methodologies with KBE Lifecycle

From the comparison, we found that none of knowledge engineering methodologies provided a tool to support activating process, due to the fact that the initiating and maintaining application did not get much attention in the knowledge engineering methodology. The application maintaining mostly depends on infrastructure of the knowledge-based system. Nevertheless, most of knowledge engineering methodologies provide tools to support from identifying to packaging process, except MOKA. It mainly focuses on capturing and formalizing process by using informal and formal models which are the core of the methodology [Stroke 01]. The project identification and justification could be done separately from the methodology. Moreover, the main objective of MOKA project is to improve manufacturing process.

II.4.3.2. Provided tools in methodology

The core of most knowledge engineering methods is capturing and formalizing the organizational knowledge. Therefore, each knowledge engineering methodology provides the knowledge elicitation and representation tools in order to support the knowledge engineer in these stages of a lifecycle. Table II.8 shows a comparison of the reviewed knowledge engineering techniques.

| **Methodology** | **KE Project Management** | **Knowledge Engineering Tool(s)** | **Knowledge Elicitation** | **Knowledge Representation** |
|---|---|---|---|---|
| **MOKA** | ICARE Model | MOKA Modeling Language (MML) | Yes | Yes |
| **SPEDE** | Swim Lane Framework | Knowledge Requirement Templates (KRTs) | Yes | Yes |
| **AKEM** | AKEM Lifecycle Model | Ontology modeling | - | Yes |
| **CommonKADS** | CommonKADS Model Suite | KADS Templates | Yes | Yes |

Table II.8: Comparing KE methodologies with provided tools

The comparison shows that each methodology provides knowledge engineering tools to assist the knowledge engineer in handling the organizational knowledge. Although AKEM methodology relies on ontology modeling to represent the knowledge, the knowledge elicitation process is still vague. This methodology concentrates more on KE project management than handling the knowledge from the expertsWe realized that this methodology is could not be recommended for a project that contains complex knowledge, such as problem solving or procedural knowledge. However, it is very useful and easy for handling less complex knowledge.



II.4.3.3. Adaptability of methodology

The difference between these tools and techniques depends on the originality and objective of the methodology. For example, MOKA methodology was developed by a project in the manufacturing domain. Thus, this methodology provides the complete tools to capture, store, represent and retrieve knowledge about manufacturing, but culture and network of organization are omitted. Thus, adaptability of the methodology to our case study is one of the critical criteria for the selection.

From the results of comparison with the first two criteria, the methodologies that seem to be suitable for our case study are SPEDE and CommonKADS methodology. These two methodologies provide adequate KE project management framework and KE tools for conducting the project identically. However, if we take a look into the details of each methodology, there are big differences between the two methodologies in many aspects.

In terms of the objective of the methodology, SPEDE and CommonKADS are focusing on the different levels of problems in the organization. SPEDE focuses on business process improvement and reengineering in the organization by using the advantages of knowledge engineering technique. The objective of this methodology is enhancing performance of the organization at the *process level* by utilizing the knowledge requirement templates (KRTs). On the other hand, CommonKADS is focusing on structuring knowledge in the organization. The objective of this methodology is enhancing knowledge intensive tasks in the organization at the *practice level* by using CommonKADS knowledge templates.

In the supporting tool aspect, tools that are provided in the methodology are the key success factor for the knowledge engineering method; they assist the knowledge engineer in knowledge elicitation and representation processes. Different functions of tools extract different types of knowledge from the experts. SPEDE provides KRTs which is a part of General Process Ontology (GPO) for extracting knowledge from the expert. These templates are well-defined method concerning the process ontology. Similarly, CommonKADS provided models and templates for each level of the framework. These templates support the knowledge engineer for knowledge elicitation in two types of knowledge task, i.e. analytic tasks and synthetic tasks. Due to these knowledge templates being flexibly defined, the knowledge engineer is able to apply this technique to different types of knowledge problems. For this reason, we believe that the CommonKADS is suitable to be adapted in our case study.

In summary, from comparison with three criteria: coverage of framework of KM project, provided tools, and adaptability of methodology, we agreed that CommonKADS is the suitable methodology for applying in our context. Therefore, the knowledge engineering processes in this study will be based on CommonKADS methodology. However, this methodology cannot be straightforwardly applied to the industry cluster. In the next chapter, we will propose adapted CommonKADS methodology for an industry cluster. The problems and solutions of applying will be discussed.