Integrating Knowledge Management into Business Processes

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CERTIFICATE OF AUTHORISATION/ORIGINALITY

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I here declare that the work described in this thesis is the result of original research and has not bee submitted for a higher degree to any other University or Institution.

I certify that all information sources and literature used are described in the thesis.

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Abstract

The 'new economy' enterprises, this thesis explains why knowledge management can fail and how the risk of such failures may be minimised. The key proposal is that knowledge management should be integrated into business processes and software agents should be used to facilitate knowledge management in business processes. The problem then is how such integration of the methodology can be applied to a concrete knowledge model.

The Evolving Knowledge Process (EKP) Model

The proposed approach includes these features: firstly, a method for developing a knowledge model; secondly, how the proposed knowledge model can be integrated into business processes; and thirdly, the use of a software agent to facilitate the integration of knowledge management into the business process; and finally, we implemented the EKP model using the Java programming language to demonstrate our system on the computer and to facilitate the use of agents.

Agents to Facilitate the Process

This thesis suggests how knowledge agents can facilitate the knowledge process. One solution is to develop a multiagent system based on the Evolving Knowledge Process (EKP) model. We defined each agent in the knowledge process to support and facilitate the process. Each agent has its own goals, plans and actions, and communicates with the other agents.

Chapter 1

Introduction

In this thesis, Knowledge Management (KM) is defined as a set of practices and processes for intellectual and knowledge-based resources in an organisation. There are multi-disciplined approaches to achieving organisational goals by using the best available knowledge. Knowledge needs to be strategically managed by organisations or individuals to maximise profits and succeed in business. It is an important and necessary issue for any organisations within this competitive global economy. The importance of knowledge management is that it involves intellectual capital, financial capital, technology, processes and infrastructure.

Research shows that more organisations are interested in knowledge management and it has increasingly played a major role in both government and private sectors. Research into knowledge management identifies various knowledge sources to integrate into knowledge management systems. Much research focuses on knowledge management processes for implementing and organising systems, but there is a lack of efficient approaches and methodologies to integrate into business processes. It is often not clear what knowledge is to be collected and who is responsible for it.

Nonaka and Takeuchi (1995) published their popular book "Knowledge Creating Company" in 1991. Their research into knowledge management was based on Japanese companies and the processes by which Japanese companies learn and create competitively valuable knowledge in organisational creativity and learning. However, their theory is very abstract and philosophical, so is very hard to integrate into business processes in practice.

This thesis suggests how to define ways to capture and convert knowledge using within-business processes. It shows how to integrate the knowledge creation activities into the business processes. Our research concentrates on this integration and ways to model it. We then describe ways of integrating these activities into collaborative processes. We also suggest that software agents be used to facilitate the integration and offer a prototype to demonstrate how agents can facilitate the process. The

following sections outline the issues in literature reviews, background theory and the problems we attempt to address.

1.1 Knowledge Management

There is no agreement on definitions of KM among researchers and practitioners. The first international conference for knowledge management , 'Knowledge; the Strategic Imperative', was held September 1995 in Houston, and the first periodicals on the topic including KM, Knowledge Inc., Knowledge Management Review and the Journal of Knowledge Management appeared in 1997, (Wigg, 1997). Some definitions of knowledge management follow.

Davenport and Prusak state that "the goal of knowledge transfer is to improve an organisation's ability to think," but they also caution that "knowledge is not the same as doing" (Davenport, 2000). Davenport's bestseller, "Working Knowledge: How organisations manage What They Know" (Harvard Business School Press), was a key publication in knowledge management in organisation.

Hansan (2003) describes KM as a complex topic of research interest to private sectors, government sectors and the community in general. However, one of the most striking aspects of knowledge management is the diversity of the field and the lack of universally accepted definitions of the term itself and its derivatives, knowledge and management.

Knowledge and its management have already been linked to organisational performance and strategy at a theoretical level. KM needs a closer tie to business strategy, and vice versa. (Leonard, 2001). This linkage takes a variety of forms and is found in the literature of evolutionary economics (Nelson and Winter, 1982), the economics of innovation and information (Arrow, 1974), and technology management and the diffusion of innovation (Teece, 1986). Knowledge has long been considered one of the key organisational resources in a resource-based view of the firm (Penrose, 1959). Knowledge has often been described as the only real sustainable competitive advantage (Winter, 1987).

KM is a cross-functional area in organisations and there is disagreement as to whether it should be considered a technical issue, a human resources issue, a procedural issue or part of strategic management (Bollinger and Smith 2001). Popular business literature portrays knowledge management as an innovation with the potential to affect the whole of an organisation's business, especially its processes and information systems (De Grooijer 2000). From a contemporary corporate perspective, knowledge management can be seen as a radical management approach for achieving cultural change in an organisation. In the current turbulent commercial environment, many firms are recognising that their organisational knowledge is an important resource for corporate success (Holsapple and Joshi 1999).

1.1.1 Important Issues in Knowledge Management in Business

Today, the economy is more competitive and organisations depend on the quality of knowledge and knowledge processes they apply to key business activities. For example, logistics and supply chain management depends knowledge of areas such as service operations management, operations management policy, productivity and quality management, and quantitative management. All these are directly related to the efficient and timely planned production/distribution, liaising with various departments, suppliers and customers, and effective reduction of costs, and also marketing management and strategic management. Management is about people, technology, ideas and concepts to enable more efficient processes to capture, store, retrieve, share knowledge for benefit of the organisation.

In the business world, the marketplace becomes very competitive and innovation in the form of new management activities such as creating new ideas, collating, collaborating, reusing, acquiring, storing and monitoring knowledge is required to meet organisational goals. For example, "Customer Knowledge" identifies the knowledge about what customers really value in products and/or services. Companies depend on long-standing relationships with their customers. Customers expect certain efficiencies from companies including lower costs and faster service. Companies must find more efficient ways to work, leveraging the knowledge of their experts. They can use knowledge management to work more efficiently. For example, the Internet is a technology to deliver services and products to customers on-line. Knowledge management provides the right information to the right people at the right time for

acquiring information and data to analyze and quickly respond. One example is Just in Time (JIT) delivery of services or products, as customers request the company and company responds with goods or services in time. There are many factors involved in knowledge management.

- Technology: to capture data, information and knowledge using internet services, on-line services and databases.
- Intellectual Capital: includes: human capital (skill, competencies, experiences),
- Customer Capital (customers, suppliers, networks).
- Structural Capital (patents, databases, trademarks, documents).
- Business Intelligence (knowledge of competitions, markets, products, etc).
- Financial Capital (stock shares, cash, credit).
- Knowledge Sharing (group and individual).
- Training.

Some organisations learn the value of knowledge when they lose it through improper use in their business processes. Other organisations manage their knowledge in mature, proactive and systematic ways to become more innovative and adaptable. They are willing to share their knowledge within the organisation and maintain focus on enterprise objectives. The most successful companies achieve their organisational goals with a balance between knowledge embedded in technologies and processes and enhanced staff capabilities and access to one another. They understand where their knowledge is and they can access it when necessary. They use technology as a tool to assist people to improve business performance. For many organisations knowledge is their product. For others, it distinguishes their products through the addition of value-added services.

KM should be a key component of any organisation's human capital strategy. Knowledge management is a growing field of interest in academia, industry and government. It refers to the processes of creating value from human capital, the organisation's structural capital and customer capital. Knowledge management has highly complex elements because knowledge and its management is about people and organisational culture. To gain the advantages of knowledge management,

organisations need to turn the individual knowledge of their members into organisational knowledge. This can be achieved through codification or personalisation strategies (Hensan et al, 1999). Codification strategies place technology at the centre of knowledge management efforts, where knowledge is codified via a people-to-document approach, and is stored in databases.

Much literature and research on knowledge management has been published over the past twenty years, mostly relating to theory. There are several approaches to knowledge management: (a) The nature of knowledge and its management in a theoretical basis of knowledge management; (b) Knowledge Management techniques include information technology, knowledge tools, measuring knowledge management, knowledge processes; and (c) Organisational Learning involves knowledge transfer, codification of knowledge and the use of knowledge with case studies and examples. Research into knowledge management remains too broad, poorly defined and philosophical, therefore hard to use in practice. People want to know how to apply theory, principle and techniques in practice.

1.1.2 Advantages of Knowledge Management for Business

Knowledge Management has been the key to success and competitive advantage for every organisation. It can help manage business processes to improve productivity through organisational efficiency, and can promote innovation. Improved organisational efficiency means that reduced process times assist technology in capturing and retrieving information and data. Knowledge management includes promoting innovation initiatives and social networks for knowledge exchange, providing leadership to encourage risk taking, and capturing the learning from past activities, (Standards Australia, 2003).

The Executive Director of the IBM Institute for Knowledge-Based Organisation, Larry Prusak, says "In the emerging economy, a firm's only advantage is its ability to leverage and utilise its knowledge". Jack Welch, former chairman and CEO of General electric (GE) (1981–2001) described the advantage of knowledge management as: "The best single lesson I ever learned was to maximize the intellect of the company. You need to gather the knowledge of individuals, share those ideas and celebrate the sharing. That, in the end, is how a company becomes great."

Knowledge management is a long-established practice in other disciplines and it can be used to produce valuable change within organisations to improve productivity, reduce production costs and improve the quality and quantity of products or services. An organisation can produce value (goods and services) by increasing demand in existing markets. Knowledge management is very useful in innovations in business that involve taking new ideas, new products or new services to markets or communities, or creating new means for producing them. This requires the creation of knowledge from different ideas and people and the exploitation of new opportunities. Many knowledge management activities are designed to achieve this outcome to establish their organisational goals and plans.

Enabling technologies can enhance knowledge management, if technologies are employed appropriately. Technologies can be used as tools to establish an environment that promotes knowledge management and knowledge sharing. Tools and methods need to be appropriate for effective use in the particular environment.

Knowledge should be retained in different formats and a variety of ways other than paper documents; otherwise, people fail to retain knowledge about significant decisions or information pertaining to complex tasks. Complex knowledge that needs to be retained for long periods, for example, can be recovered by document, verbal, multimedia application and communicating with people.

1.1.3 Relationship of Knowledge Management to Other Disciplines

Knowledge management is multi-disciplinary. It integrates different areas in business and academic disciplines, including: information technology, supply chain management, law firms, social sciences, e-commerce, organisational learning and business processes. KM is interdependent with other programs such as business process management; human change management and IT project management. By applying knowledge management in these areas, businesses can leverage the best practices of KM into their business, process, and technology change management. These different disciplines depend on the way knowledge is managed, whether it is created or being used. If new knowledge is being created, then disciplines are important. The disciplines help in innovating, improving productivity, organisational learning, business intelligence and communities of practice.

For example, if existing knowledge is being used, then concepts such as organisational learning, business intelligence and communities of practice can play important roles. There are other disciplines that are important in ensuring that knowledge assets are effectively used. If knowledge management is valued in particular circumstances, then highly inclusive and emerging disciplines will be incorporated. The important thing is that integration of other disciplines with knowledge management is a significant improvement on each discipline performing independently.

1.1.4 Importance of the Context

In an organisational context, data represents facts or values of results, and the relationships between data values and other relations are what represent useful information. Patterns of relations of data and information and other patterns represent knowledge. If representations of patterns are to be of any utility, they must be understood, and then those representations are information or knowledge to the one that understands.

For example, in the context of logistics and the supply chain, a manager has knowledge, especially in "operations management, service operations management, operations management policy, productivity and quality management, and quantitative management" that is directly related to the points of "efficient and timely planned production/distribution, liaising with various departments, suppliers and customers, and effective reduction of costs". In this context, knowledge management includes managing intellectual capital, such as best practice, operating management, and business processes. Establishing ongoing processes for acquiring, organising and distributing knowledge about customer relationship management and core business operations in business strategies is important in this context.

1.2 Major Issues in KM

1.2.1 Current Issues in KM

Organisations have long appreciated the value of knowledge in enhancing their products and customer service. Many organisations rely on knowledge to create their strategic advantage. If available knowledge is dispersing, organisations can waste

time and resources to access the highest quality knowledge that is available. Companies adopt two broad thrusts in applying knowledge management: (Skyrme, 2000):

- Sharing existing knowledge better – making implicit knowledge more explicit and putting in place mechanism to move it more rapidly to where it is needed;
- Innovation – creating and making the transition from ideas to commercialisation more effective.

(a) Knowledge Sharing

Knowledge sharing within organisations comes from an awareness of the necessity to stimulate circulation of knowledge. With the emergence of a knowledge economy in which people in organisations gain more knowledge specific to their tasks, organisations need to make their dispersed knowledge domains more visible, so that people know what everyone else knows; they will communicate with each other to exchange their knowledge more effectively as well as with customers and clients.

Knowledge sharing by individuals through knowledge repositories may be understood in terms of two distinct activities, contributing knowledge and seeking knowledge. Contributing and seeking knowledge are two complementary concepts, being parts of the same higher-order concept of knowledge sharing. For an individual, contributing and seeking knowledge through knowledge repositories tend to be independent, discrete, and asynchronous activities (Zack, 1999). Knowledge sharing can be classified into five levels: the individual, the organisation, the technology, the task and the knowledge itself (Mehra and Bandi, 2003). To gain the advantage of knowledge management, organisations need to turn the individual knowledge of their members into organisational knowledge. This can be achieved through codification or personalisation strategies (Hansen et al. 1999). The whole activity of knowledge sharing or transfer is generally seen as a key element of knowledge management (Davenport and Prusak, 1998).

(b) Knowledge Innovation

Knowledge innovation means the creation, evolution, exchange and application of new ideas into marketable products and services for the success of the business, in

addition to building a foundation for future sustainable growth. It recognises that knowledge is the core component of innovation, not technology or financial capital. Effective knowledge management is a necessary prerequisite for innovation that encompasses the full spectrum from creative idea generation through full commercialization. Successful innovation depends on converting knowledge flows into goods and services. Through technology development and communication systems, enterprises will have to become far more innovative in how they partner with customers to create, transfer, and apply new knowledge within and across industries.

1.2.2 Practice in KM

KM involves strategies, implementation, processes and developing strategic plans in an organisation. The challenge that most companies are facing is for faster innovation. Most companies today profit from only a small part of their knowledge assets. How do they find where the knowledge base is located and how do they find the knowledge resources? What are the cost and benefit of their goods and services for customers and what should need to be changed for tomorrow? How much would the company lose if its most valuable employee left without sharing his/her acquired experience and knowledge? A business organisation should know "what it knows", and then it can perform very well and be a successful business. Most successful companies create "Knowledge Sharing" (intellectual and human capital) as an effective way to produce successful and continual innovation.

1.2.3 Practical Principles for KM

Many companies are beginning to feel that the knowledge of their employees is their most valuable asset. Knowledge management has thus far been addressed at either a philosophical or a technological level, with little pragmatic discussion on how knowledge can be managed and used more effectively on a daily basis. Davenport (1998) describes in his PhD thesis ten principles of knowledge management:

1. Knowledge management is expensive (but so is stupidity!).
2. Effective management of knowledge requires hybrid solutions of people and technology.
3. Knowledge management is highly political.
4. Knowledge management requires knowledge managers.

5. Knowledge management benefits more from maps than from models, more from markets than from hierarchies.
6. Sharing and using knowledge are often unnatural acts.
7. Knowledge management means improving knowledge work processes.
8. Knowledge access is only the beginning.
9. Knowledge management never ends.
10. Knowledge management requires a knowledge contract.

Alle (1997) describes knowledge as always changing. In an organisation, knowledge changes around products, services, processes, technology, structures, roles and relationships. She defines principles of knowledge management that help to identify processes, structures, and organisational enablers that support the creating, sustaining, sharing and renewing of knowledge (Kauffman, 1980). These principles are:

1. Knowledge is "messy".
2. Knowledge is self-organisation.
3. Knowledge seeks community.
4. Knowledge travels on language.
5. Knowledge is slippery.
6. Looser is probably better.
7. Knowledge keeps changing.
8. Knowledge does not grow forever – something eventually dies or is lost.
9. No one is really in charge.
10. You cannot impose rules and systems.
11. There is no silver bullet.

How you define the knowledge "problem" determines what and how you try to manage.

1.2.4 The Wrong Issues in Current KM

KM is a crucial issue in the business world. Many researchers and practitioners view KM as one of the few sustainable sources of competitive advantage. However, knowledge management is not well supported by theory. Therefore, there is a lack of progress in research and practice. This section addresses the problematic situations as they affect current knowledge management in both research and practice.

We consider some research questions as follows:

- What is the research evidence on setting right framework or methodology for knowledge management in practice?
- Which knowledge management theories can support the business world?
- Why are knowledge management theories more philosophy than practice?

Our own perception is that knowledge management research in academic and enterprise settings has many directions and different methodologies. There are many arguments in research and practice. This situation makes it difficult to progress in knowledge management in either academia or the enterprise.

We might argue that knowledge management researchers and practitioners would be hungry for reliable theory and concepts about what methodologies to improve knowledge management; keen to work with other researchers and practitioners to identify and address pressing research questions; and eager to collaborate to develop methodologies that can be used in practice.

In our view, however, the research findings appear to play a major role in the different backgrounds of researchers and organisational goals. Nonaka and Takeuchi (1995) consider that the Western and Eastern worlds have different views of knowledge management. We argue that there will not be only one theory like Newton law's of motion or Einstein's relativity theory in knowledge management.

Here are some reasons that were pointed out by Stewart (2002) which describe failures of KM:

- More often than not the knowledge management initiative was not properly or clearly scoped and the objectives, even the short term ones, were not clear.
- Poor communication between the parties of interest, and those who were most affected by the changes brought on by the implementation of knowledge management.
- Lack of commitment and lack of support across the enterprise: more lip service than real commitment.

- The knowledge management change process and implementation took too long.
- The knowledge management program was too technology-centric and the people element was all too often ignored or side-stepped.
- The absolute link between knowledge and the business processes where it is created and used has not been clearly understood or appreciated.

Every business needs to implement good knowledge management system in this modern world. In the following sections, we will discuss how to solve these problems and overview or our research.

1.2.5 Scoping the problems and addressing current issues

We can now scope our problem and address current issues before doing research. This leads to the following perceptions:

i. *A clear sense of purpose*

What is the purpose of knowledge management research? If we do have a purpose for research as researchers, what is it?

The purpose of knowledge management is to find ways to improve processes for intellectual and knowledge-based resources in organizations. We can describe knowledge management for knowledge control in an individual or organization as *know-how* and *know-what* to effectively manage knowledge.

ii. *Focused research questions*

Do we believe that we can find a clear way to develop a methodology or framework for knowledge management?

Many research studies in knowledge management focus on the theory and philosophy, but few address the methodology used in practice (Nonaka and Takeuchi, 1995). There is a lack of studies of the integration of knowledge management processes into business processes. We will discuss the knowledge management framework (methodologies) in the business world in Chapter 2.

iii. ***Useful research syntheses***

Are our research projects and methods so varied and idiosyncratic as to reader them impossible to use?

Researchers and practitioners use syntheses of past research to assist in their current research. They could benefit from much more convenient access to available research findings to progress. They might consider "What does the research evidence say about the methodology or framework that can be used in practice?"

iv. ***Improved dissemination***

Do we believe that the dissemination and acceptance of research findings is appropriate for practice?

The key to ensuring that research serves practical knowledge management is the development of better methodologies and theories and making them available to practitioners. Better dissemination might also be achieved through the use of surveys of knowledge management research in different directions such as culture (including leadership and organisational learning), intellectual capital, practice of KM, KM as process, social capital and networking (e.g. communities of practice), technology, theories about knowledge (Edwards, Handic 2003).

These are the challenges in scoping the problems in knowledge management research for both academics and practitioners. We should carry out research on those points that can support clear views and form the motivation for the research.

1.2.6 Overview of the Research

(a) Research Objective

To develop a formal knowledge model that can be defined as a sequence of activities and resources for a knowledge creation model. We are basing our "Evolving Knowledge Process (EKP) Model" on the approach used by Nonaka and Takeuchi (1995) for the general practical process.

(b) Methodology

Our research finds that there are two kinds of important processes: the first is the knowledge management process and the second is the business processes. We want to study how to integrate these two processes.

(c) Scope of current research

There are different methodologies and theories in current knowledge management research and practice. We need to choose a knowledge model that can be applied in practice.

(d) Suitability and use

Our research methodology needs to be suitable and useful in business processes. Most methodologies are theories and philosophy. Knowledge management means improving knowledge work processes (Wigg, 1998), but knowledge is generated, used, and shared intensively in a few specific knowledge work processes. If we want real improvements to be made in knowledge management, we need a practical methodology that can be used in practice. Every business strategist can assent to the good vision of implementing effective knowledge management in business. Researchers and practitioners agree that the KM disappointments and losses have been significantly greater than the delivered results. Initially, KM's failure to achieve goals has been the focus of discussion amongst researchers and business analyst in business world.

1.3 The Structure of this Thesis

Chapter 2 explains the literature review, direction of knowledge management in research and practice, knowledge management frameworks in the business world, background theory, importance of the thesis, hypothesis of research and outcomes of research and suggested methodology in practice.

Chapter 3 then develops a methodology for knowledge processes. The research objectives and research approach to developing knowledge models are given. It also describes contributions and research methodology.

Chapter 4 then proposes details of the knowledge model for knowledge management that involves detailed steps in the knowledge creation process.

Chapter 5 discusses how our knowledge model compares to Nonaka's knowledge model.

Chapter 6 explains a method for integrating knowledge management into business processes and its application. Supply change management and online learning are used as examples.

Chapter 7 describes an agent support model that facilitates the knowledge management process. It discusses the agent structure for the knowledge model and shows how the agents and the KM process interact.

Chapter 8 describes the implementation of the knowledge model using software agents to simulate the EKP model.

Chapter 9 then concludes this thesis by giving a summary of the points presented, contributions made and opportunities for future research.

Chapter 2

Literature Review

Knowledge Management is now widely used. It is used in consulting firms and the academic and private sectors. KM has its roots in a variety of disciplines and domains such as information technology, business processes, and information management. In general, it attempts to create knowledge in such contexts as the organisation's products or services. To some extent its point of departure is within the resource-based view of the company, which focuses on the development of competencies, and the knowledge-based theory of the firm that suggests that knowledge is the organisational asset that enables sustainable competitive advantage in today's hypercompetitive environment (Hartmann, 1998). Knowledge management theories and frameworks have practical views on how knowledge management can be managed and used more effectively. Knowledge management is an evolving discipline that can be affected by new technologies and best practices.

This chapter discusses the two approaches of theoretical framework and practice in knowledge management research. Some theories are very good but are difficult to apply in practice fully. The research focuses on both theory and practice in business processes. The following sections will present a literature review of different kinds of knowledge management frameworks and background theory, and will present the hypothesis of our research and its expected outcome.

2.1 Knowledge Management has many research dimensions

Knowledge management is a very broad umbrella and covers academic, private and government organisations. It is concerned with the invention, improvement, integration, usage, administration, evaluation, and impacts of different directions and methodologies in practice. Most research focus on significant implications for individual effectiveness within organisations and organisational competitiveness in business. There are many research directions in knowledge management areas in business processes.

Knowledge management is one of the most popular topics in the business world, (Srikantaiah and Koenig 2000) and many practitioners in different disciplines have become active partners in embracing this area. Knowledge management includes people and the use of technology to enable more efficient processes to capture, store, retrieve, use, re-use and share knowledge for business organisation. Knowledge management is important to organisations for business success, but there is a lack of understanding of the phenomenon itself and a lack of proven techniques for managing the knowledge resource in organisations (Hasan, 2003). However, there are dangers in placing too much dependence on the different research areas and directions. These include:

- a lack of objectivity, as those involved in KM initiatives are not always the best judges of their long term benefits; and
- a lack of generality, as KM methods are usually context dependent and not easily transferred from one organisation to another (Hasan, 2003).

Research into KM investigates the KM frameworks (methodologies and tools) and models through case studies, experiments, and implementation and analysis. Organisations are searching for new ways to prepare and survive in the increasingly competitive environment. The most popular strategic change management approaches (Davenport and Prusak 1997) have emerged in knowledge and information management in dawn of the 21st century, (Spiegler, 2000). The knowledge creation process (Nonaka and Takeuchi, 1995) is one of the competitive advantages in knowledge management research.

Many researchers have different directions and approaches in knowledge management research areas such as computer science, information systems, artificial intelligence, management science, cognitive sciences, psychology, linguistics, collaborative work processes, employee empowerment and knowledge ontology. The categories of knowledge management research include knowledge generation (e.g. agents, pattern recognition), knowledge representation (e.g. indexing, ontologies, semantics), knowledge in learning environments and knowledge visualisation (e.g. interfaces, virtual environment).

Some research focuses on computer-supported tools (Ruggles, 1997) for knowledge management. Pattern recognition research (Brash, 2000) studies how to extract knowledge from patterns of data used in computer-supported work. Enterprise Systems (ES) is a knowledge-intensive task for implementing comprehensive IT applications (Rosemann and Chan, 2001) to better leverage knowledge resources. Hains and Goodhue (2000) suggest that transferring and retaining knowledge within the organisation becomes essential thereafter to the overall success of an ES implementations.

Other research directions are in tacit knowledge (initiated by the Hungarian-born Oxford chemist turned philosopher, Polanyi, (1958; 1967; 1968)). In tacit knowledge research, few researchers (Donaldson 2001; Horak, 2001) can measure this knowledge, although Sternberg's (1999) approach could be used in practice. Nonaka (1995) and Lam (2000) work in organisational knowledge that combines tacit and explicit knowledge to create new organisational knowledge. Nonaka's knowledge creation process was applied in Japanese companies to innovate organisational knowledge.

Organisational learning or knowledge acquisition is the amplification and articulation of individual knowledge at the firm level so that it is internalised into the firms' knowledge base (Inkpen, 1995, Nonaka and Takeuchi, 1995). Organisational learning involves a complex interplay between the individual and the firm (Cohen, 1991; Nonaka and Takeuchi, 1995; Spender, 1996).

Pollard (2000) identifies possible strategies, leading practices, and pitfalls to avoid in knowledge transformation processes. His research explores the challenges involved in identifying and measuring intellectual capital, encouraging new knowledge creation, capturing human knowledge in structural form, and enabling virtual workgroup collaboration.

There are several international research teams who have applied the Russian psychologist Vygotsky's (1978) work in activity theory in their research such as organisational theory (Blacker, 1993), organisational learning (Engestrom, 1999) and organisational sense-making (Hasan, 2000). The Hasan approach provides a framework for collections of people in organisations engaged in innovative activities

that contribute to learning and knowledge creation. (Cecez-Kecmanovic, et, al 2001) investigate the social dimension of knowledge in an organisational context. They focus on knowledge as both a subject and a product of sense-making by individuals, groups and organisations. Their proposed model of knowledge management identifies respective types of knowledge: individual, collective, organisational and cultural knowledge.

Vicari and Troilo (2000) used cognitive systems theory to analyse the relationships between creativity and knowledge management in firms. The management of creativity and knowledge generation is based on the active generation of crises and crisis leverage within the firm.

Background theory for our research is described in the next section.

2.2 Background Theory

Knowledge Model (1): Michael Polanyi's Model

Polanyi's (1962) concept of knowledge is based on three main issues: (1) True discovery cannot be accounted for by a set of articulated rules or algorithms. (2) Knowledge is public and also to a very great extent personal (i.e., it is constructed by humans and therefore contains emotions, or "passion"). (3) The knowledge that underlines the explicit knowledge is more fundamental; all knowledge is either tacit or rooted in tacit knowledge.

The SECI Model (2): Nonaka's Knowledge Creation Process

Nonaka and Takeuchi's (1995) theory of knowledge creation is based largely on their analysis of innovative Japanese companies. They draw on Michael Polanyi's (Polanyi, 1962) distinction between tacit knowledge and explicit knowledge. Tacit knowledge is personal, context-specific, and therefore hard to formalise and communicate. Explicit or "codified" knowledge, on the other hand, refers to knowledge that is transmittable in formal, systematic language. The Socialisation, Externalisation, Combination, Internalisation (SECI) is a model of the knowledge creation process to help understand the dynamic nature of knowledge creation, and to manage such a process effectively. It consists of 3 elements: *SECI*, *Ba* and *Knowledge Assets*. These 3 elements interact with each other organically and dynamically. The knowledge

assets of an organisation are mobilised and shared in *Ba* whereas the tacit knowledge held by individuals is converted and amplified by the spiral of knowledge through *Socialisation, Externalisation, Combination and Internalisation*, Figure 2-1.

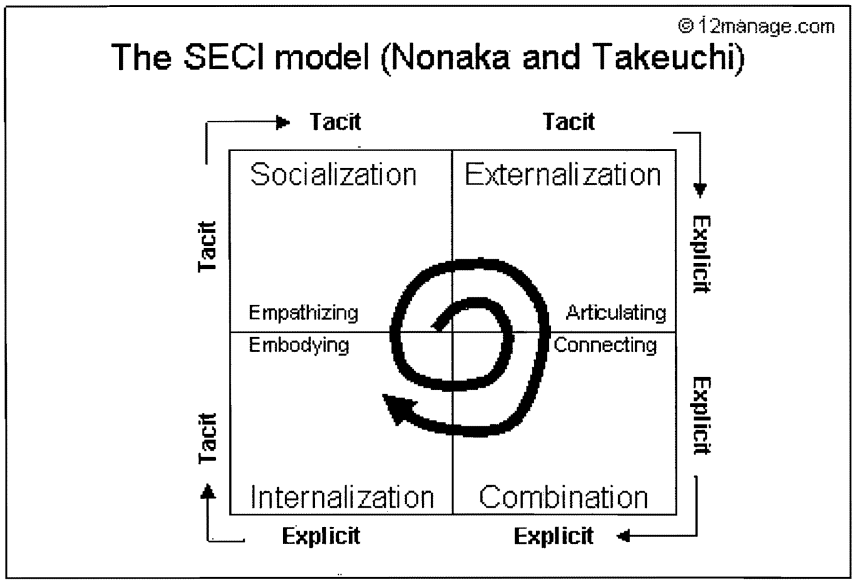

Figure 2-1. Nonaka and Takeuchi's knowledge creation process (The SECI Model)

Socialisation (S) is a process of acquiring tacit knowledge through sharing experiences. Nonaka and Toyama (2003) contend that knowledge creation starts with socialisation, which is the process of converting new tacit knowledge through shared experiences in day-to-day social interaction. Since tacit knowledge is difficult to formalise and often time and space-specific, tacit knowledge can be acquired only through shared direct experience, such as spending time together or living in the same environment, typically a traditional apprenticeship where apprentices learn the tacit knowledge needed in their craft through hands-on experiences.

Externalisation (E) is a process of converting tacit knowledge into explicit concepts through the use of metaphors, analogies, or models. Tacit knowledge is made explicit so that it can be shared by others to become the basis of new knowledge such as concepts, images, and written document. During the externalisation stage, individuals use their discursive consciousness and try to rationalise and articulate the world that surrounds them (Nonaka and Toyama, 2003). Here, dialogue is an effective method to articulate one's tacit knowledge and share both tacit and articulated knowledge with others. The sequential use of metaphor, analogy, and model is a basic method in abduction (Lawson, 1998).

Combination (C) is a process of creating explicit knowledge, bringing together explicit knowledge from a number of sources. Explicit knowledge is collected from inside or outside the organisation and then combined, edited, or processed to form more complex and systematic explicit knowledge through the combination process, (Nonaka and Takeuchi, 1995).

Internalisation (I) is a process of embodying explicit knowledge into tacit knowledge, internalizing the experiences gained through the other modes of knowledge creation into individuals' tacit knowledge bases in the form of shared mental models or work practices (Nonaka and Takeuchi, 1995). This stage can be understood as praxis, where knowledge is applied and used in practical situations and becomes the base for new routines. Thus, explicit knowledge, such as product concepts or manufacturing procedures, has to be actualised through action, practice, and reflection so that it can really become knowledge of one's own.

Ba

Nonaka and Konno (1998) introduced the concept of 'Ba', a Japanese word with a special meaning of the concept of 'place', to address the question of fundamental conditions for knowledge creation.

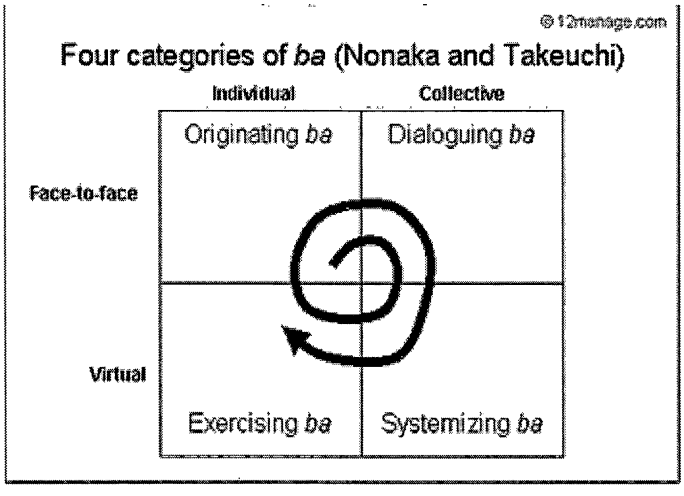

Figure 2-2. Four categories of ba (Nonaka and Takeuchi)

They suggested that four types of 'Ba' (originating, interacting, dialoguing and exercising) act as promoters of processes of socialisation, externalisation, combination and internalisation (SECI) and so enable knowledge creation. 'Ba' is a

difficult concept (there is no exact translation of the word) that can be defined as a shared context in which knowledge is shared, created and utilised through interaction. Figure 2-2 illustrates the various types of Ba, each offering a context for a specific step in the knowledge creating process. Nonaka's study at Seven-Eleven (Japanese convenience shops) describes the categories as follows:

Originating Ba: the shop floor, it enables people to interact with each other and with customers.

Dialoguing Ba: the tacit knowledge of local employees is used to create sales forecasts, in dialogue with each other.

Systemizing Ba: the forecasts of sales are tested against the sales results and are fed back to the local stores.

Exercising Ba: using this information, and comparing it to reality, staff improve their skills and ability to make the forecasts.

Knowledge Assets

Nonaka and Takeuchi describe how to effectively manage knowledge creation and exploitation. They identify four categories of knowledge assets a company has to 'map' in its inventory of knowledge assets. Knowledge assets are dynamic; new knowledge assets can be created from existing knowledge assets.

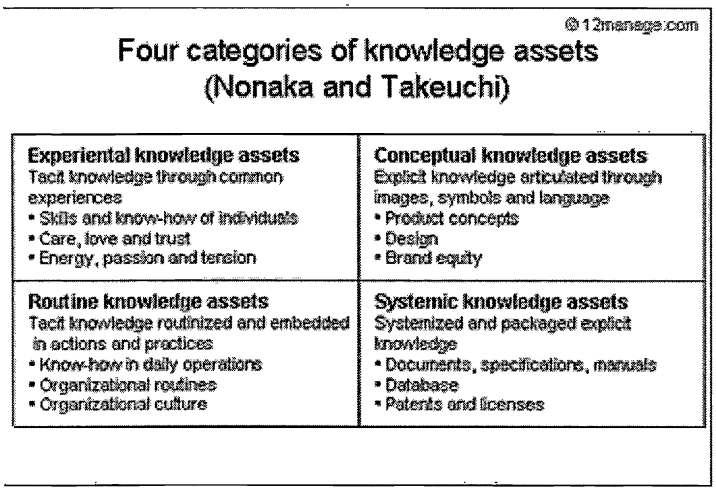

Figure 2-3 Four categories of knowledge assets (Nonaka and Takeuchi)

Nonaka and Takeuchi based their model on Polyani's distinction between tacit and explicit knowledge (1983). It provides an understanding of knowledge and management from a Japanese business culture perspective.

2.2.1 Differences between Polanyi's Model and Nonaka's Model

There are differences between two knowledge models:-

(a) Polanyi's Model

(1) How human beings acquire and use knowledge it is action oriented and about the process of knowing.

(2) He does not apply his concept to a particular industry, organisation or department.

(b) Nonaka and Takeuchi's Model

(1) Draws on Polanyi's distinction between tacit and explicit knowledge

(2) Based largely on the analysis of innovative Japanese companies

(3) Four kinds of knowledge conversions (socialisation, externalisation, combination, internalisation)

(4) Knowledge creation happens within places (Ba)

(5) Effectively manages knowledge creation and exploitation in company

(6) Describes four categories of knowledge assets

To compare these two models, Nonaka's model is more practical and has many case studies in Japanese companies to apply in research. However, this model is still too abstract and doesn't show detailed steps in knowledge creation process. Therefore, research needs to develop a concrete and structured knowledge model that can be applied to business processes.

2.3 Knowledge Management Frameworks in the Business World

Many frameworks focus on knowledge processes and integrating KM into the strategic goals of the organisations. The goals of KM frameworks are strategy, culture, characteristics of knowledge, organisational structures to support knowledge, and performance. A KM framework provides various tools (methods, practice and technologies). It provides a high-level overview of a number of concepts and key

terms, and describes the framework, provides example of how to use it, and explores potential application areas.

Table 2-1 shows some different types of frameworks being used (or proposed) by industry and academia, (Alavi, 1999; Alavi and Leidner, 2001; Hosapple and Joshi, 1999; Rumizen, 2002).

First, most of the knowledge management frameworks or methodologies to date are not comprehensive in terms of covering end-to-end concepts. Many of these frameworks focus only on the knowledge cycle process and do not cover other critical elements of knowledge management such as integrating knowledge management into the strategic goals of the organisation.

Second, few knowledge management frameworks include double-loop learning (i.e., learning how to learn, learning and unlearning), and this is a major omission. Iterative feedback within and between knowledge management phases is an important element in a knowledge management framework to create a learning organisation.

Third, most of the organisations that either had or were developing a knowledge management system felt that it was designed to achieve both process results and organisational outcomes. This finding was consistent with (Alavi, March, 2001). Sometimes it is difficult to achieve both goals at the same time.

Fourth, the knowledge management framework should not concentrate simply on the technology infrastructure, but should spend even more time on the organisational and cultural aspects (Alavi, 1999). Knowledge management frameworks mostly focus on organisational and cultural aspects rather than technology infrastructure.

Table 2-1 A sample of knowledge management frameworks.

FRAMEWORK	DESCRIPTION
(Alle, 1997)	1. Data (feedback), 2. Procedural (efficiency), 3. Functional (effectiveness), 4. Managing (productivity), 5. Integrating (optimisation), 6. Renewing (integrity).
American Management System (Smith, 1999)	1. Find (create knowledge centres), 2. Organise (motivate and recognise people), 3. Share.
Dataware Technologies, Inc. (Dataware 1998)	1. Identify the business problem, 2. Prepare for change, 3. Create the KM team, 4. Perform the knowledge audit and analysis, 5. Define the key features of the solution, 6. Implement the building blocks for KM, 7. Link knowledge to people.
Buckle and Carter Centre for International Business, University of Leeds (Buckle and Carter, 1998)	Business process approach to knowledge management (no formal methodology but key knowledge processes are identified): 1. Knowledge characteristics, 2. Value added from knowledge combination, 3. Participants, 4. Knowledge transfer methods, 5. Governance, and 6. Performance.
The Delphi Group (Delphi, 1999)	Specifics about a methodology have not been released, but the following are addressed: 1. Key concepts and frameworks for knowledge management, 2. How to use knowledge management as a competitive tool, 3. Cultural and organisational aspects of knowledge management, 4. Best practices in knowledge management, 5. The technology of knowledge management, 6. Market analysis, 7. Justifying knowledge management, and 8. Implementing knowledge management.
Ernst and Young (Ernst and Young, 1999)	1. Knowledge generation, 2. Knowledge representation, 3. Knowledge codification and 4. Knowledge application.
Holsapple and Joshi Kentucky Initiative for Knowledge Management (Holsapple and Joshi, 1998)	1. Acquiring knowledge (including extracting interpreting and transferring), 2. Selecting knowledge (including locating, retrieving and transferring), 3. Internalising knowledge (including assessing, targeting, and depositing), 4. Using knowledge, 5. Generating knowledge (including monitoring, evaluating, producing, and transferring), and 6. Externalising knowledge (including targeting, producing, and transferring).
Knowledge Associate (Young, 1999)	1. Acquire, 2. Develop, 3. Retain, 4. Share.

FRAMEWORK	DESCRIPTION
The Knowledge Research Institute (Wigg, 1998)	1. Leverage existing knowledge, 2. Create new knowledge, 3. Capture and Store Knowledge, 4. Organise and transform knowledge and 5. Deploy knowledge.
Liebowitz (Liebowitz and Beckman, 1998)	1. Transform information into knowledge, 2. Identify and verify knowledge, 3. Capture and secure knowledge, 4. Organise knowledge, 5. Retrieve and apply knowledge, 6. Combine knowledge, 7. Learn knowledge, 8. Create knowledge (loop back to 3.), and 9. Distribute/sell knowledge.
Marquardt (Marquardt, 1996)	1. Acquisition, 2. Creation, 3. Transfer and utilisation, and 4. Storage.
Monsanto Company (Junnarkar, 1997)	No formal knowledge management methodology; use learning maps, value maps, information and knowledge maps, measurements, and information maps.
The Mutual Group (Saint-Onge, 1998)	Capital framework; 1. Gathering information (building an explicit knowledge infrastructure), 2. Learn (tacit knowledge development), 3. Transfer and 4. Act(developing capability through values deployment).
The national Technical University of Athens, Greece (Apostolou and Mentzas, 1998)	1. Context (generating knowledge), 2. Knowledge management goals (organising knowledge), 3. Strategy (developing and distributing knowledge), and 4. Culture.
O'Dell American Productivity and Quality Centre (O'Dell, 1996)	1. Identify, 2. Collect, 3. Adapt, 4. Organise, 5. Apply, 6. Share, 7. Create.
Price Waterhouse Coopers (Steiner, Huffman, 1997)	1. Find, 2. Filter (for relevance), 3. Format (to problem), 4. Forward (to right people), and 5. Feedback (from users).
Ruggles (Ruggles, 1997)	1. Generation (including creation, acquisition, synthesis, fusion, adaptation), 2. Codification (including capture and representation), 3. Transfer.
Skandia (Skandia, 1999)	Universal Networking Intellectual Capital: Emphasizes 1. Networking and knowledge sharing, 2. Knowledge navigation by project teams, 3. Intellectual capital development tool box.

FRAMEWORK	DESCRIPTION
Van der Spek and de Hoog (Van der Spek and de Hoog, 1998)	1 Conceptualise (including make an inventory of existing knowledge and analyse strong and weak points), 2. Reflect (including decide on required improvements and make plans to improve process), 3. Act (including secure knowledge and develop knowledge), 4 .Review (including compare old and new situation and evaluate achieved results).
Van der Spek and Spijkervet (Van der Spek and Spijkervet, 1997)	1. Developing new knowledge, 2. Securing new and existing knowledge, 3. Distributing knowledge, 4. Combining available knowledge.
Van Heijst et al. CIBIT, Netherlands (Van Heijst and Kruizinga, 1997)	1. Development (Creating new ideas, analysing failures and examining current experiences), 2. Consolidation (storing individual knowledge, evaluation and indexing), 3. Distribution (informing users), 4. Combination (combining disparate information and increasing access to distributed data).
Wielinga et al. University of Amsterdam (Weilinga, Sandberg, 1997)	Apply CommonKADS methodology to knowledge management: 1. Conceptualise (identify/inventory, represent, classify), 2. Reflect (models of knowledge development and creation, models for identifying knowledge resources and results) and 3. Act (combine and consolidate knowledge, integrate knowledge, develop and distribute knowledge).
Wigg (Wigg, 1993)	1. Creation and sourcing, 2. Compilation and transformation, 3. Dissemination application, 4. Value realisation.

The above table describes the existing knowledge management frameworks in global knowledge management research and practice. Knowledge management might be better accepted as a discipline if discipline-wide, unifying theories and principles could be integrated with knowledge management processes, methodologies, tools and techniques (Liebowitz and Rubenstein-Montano, 2001).

In the first finding, (Liebowitz, et al 2001) the frameworks focus on task-based aspects such as strategic goals of organisation rather than on other aspects of knowledge management, (Liebowitz and Rubenstein-Montano). There are some examples of this in the table: Ernst and Young (Ernst and Young, 1999), Knowledge Associates (Young, 1999), the Knowledge Research Institute, Inc, (Wigg, 1998), Liebowitz (Liebowitz and Beckman, 1998), Marquardt (Marquardt, 1996), O'Dell American Productivity and Quality Centre (O'Dell, 1996) and Ruggles (Ruggles,

1997). These frameworks describe knowledge management activities and knowledge flows but they don't address factors that influence the knowledge cycle. Beyond that, some of the examples in the table involve knowledge acquisition tasks, such as Price Waterhouse Coopers (Steiner, Huffman, 1997) and (Liebowitz, 1999). Some examples of knowledge-creating concepts are Ernst and Young (Ernst and Young, 1990), Universal Networking Intellectual Capital (Skandia, 1999), (Liston, and Schoene, 1971). Organising knowledge (Liston, and Schoene, 1971) and sharing knowledge (Liston, and Schoene, 1971), Price Waterhouse Coopers (Steiner, Huffman, 1997), and using and applying knowledge Ernst and Young (Ernst and Young, 1999).

In the second finding (Liebowitz, et al 2001), some of the examples that focus on learning (double loop learning and single loop learning) are: a three-fold framework (Holsapple and Joshi, 1997) and descriptive framework for knowledge management (Holsapple and Joshi, 1998). Holsapple and Joshi identify learning as an outcome of knowledge management in general. The American Productivity and Quality Centre's (O'Dell, 1996) research into knowledge management and knowledge transfer in best practice includes Ruggles's research activity of generation and codification of knowledge (Ruggles, 1997) and developing new knowledge (Van der Spek and Spijkervet, 1997). Learning is more important for facilitating an approach to knowledge management and reflecting cultural and intellectual concepts as well as the culture of the organisation and its goals.

The third finding (Liebowitz, et al 2001) is that more consistency is required in knowledge management initiatives and disciplines in the framework. For example, the Delphin Group (Delphin, 1999) addressed the key concepts and frameworks for knowledge management, tools, cultural and organisational aspects and best practice, but not learning or linkages with strategic business objectives. The business process approach to knowledge management framework of the Centre for International Business, University of Leeds, and (Buckley and Carter, 1998) emphasizes business processes and introduces governance and performance.

The fourth finding refers to the difference between organisational and structural frameworks. Examples are the Holsapple and Joshi model, which involves acquiring

and selecting knowledge and internalising, using and externalising knowledge (Hosapple and Joshi, 1998), and van der Spek and Spijkervet (1998). However, they do not prescribe a particular flow for the framework.

Knowledge management should be a necessary and important part of an organisation's management and performance. It should be a key component of any organisation's strategy. Knowledge management cannot be thought of in the same way as general information systems management. Knowledge management must include significant planning to define an organisation's problems and objectives prior to undertaking knowledge management tasks, (Liebowitz and Rubenstein-Montano, 2001). Most of the frameworks include similar elements but are structured differently, suggesting that a set of distinct, linear tasks may not be appropriate for knowledge management. The knowledge management process needs design and multiple activities to occur simultaneously during the process.

The knowledge management framework (Table 2-1) is shown in Figure 2.2 below.

2.3.1 Knowledge Management (Framework and Methodology)

The threaded tenets, phases, tasks, and deliverables of the proposed knowledge management framework are described in (Montano, et. al, 2001). Figure 2-2 illustrates the knowledge management framework.

Threaded Tenets Throughout the Phases:

- Project management
- Technical/process reviews
- Change management
- Process training
- Quality assurance

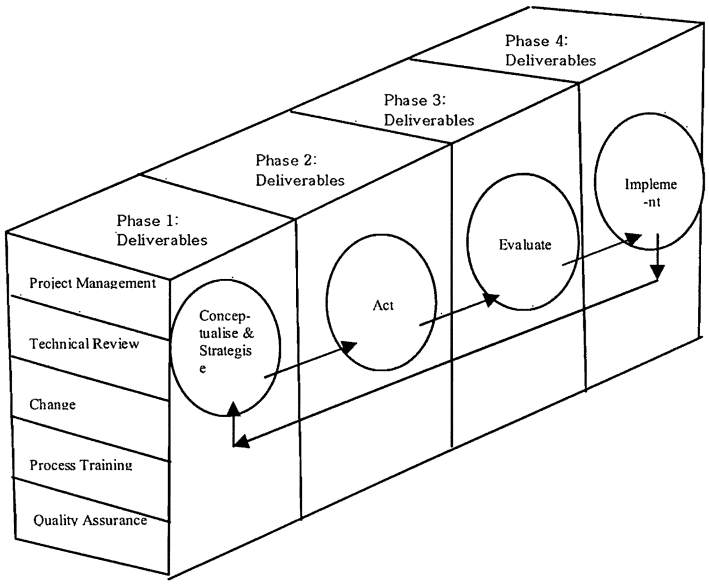

Figure 2-2 Knowledge management framework (Monato, et. al, 2001)

Phase 1: Conceptualise Strategise

- Business Problem Identification
- Knowledge Audit
  - Identify and verify knowledge
  - Perform knowledge mapping
  - Analyse strong and weak points
  - Perform gap analysis
  - Provide recommendations
- KM Strategy Planning
  - Plan the KM strategy
  - Build a supportive knowledge sharing culture, including a motivate/reward system
  - Establish a KM infrastructure, organisationally and technologically
  - Create and define knowledge-related alternatives and potential benefits
  - Portray benefit-cost-risk analysis of KM activities
  - Set KM priorities

Phase 1 Deliverables:

- Business Needs Analysis Document
- Knowledge Audit Document (including knowledge map)
- Cultural Assessment Document
- KM Strategy Plan (including an implementation plan)

Phase 2: Act

- Capture and secure knowledge
- Represent and organise knowledge into a knowledge taxonomy and repositories
- Retrieve and apply knowledge
- Combine knowledge
- Learn knowledge and cycle back up to capture knowledge
- Distribute or sell knowledge

Phase 2 Deliverables:

- Knowledge Acquisition Document
- Knowledge Relationship Chart
- Knowledge Repositories/KM System Mark I

Phase 3: Evaluate

- Review and compare old and new situations and look for value-added benefits
- Test and evaluate achieved results

Phase 3 Deliverables:

- Evaluation Methodology and Results Document
- KM Strategy Mark II version
- User's Guide for KM System

Phase 4: Implement

- Coordinate KM activities and functions
- Create and market integrated knowledge transfer programs

- Monitor KM activities
- Conduct post-audit
- Expand KM infrastructure where appropriate

Phase 4 Deliverables:

- Maintenance document for KM System
- KM full Production system
- Post-Audit Report

Another area for improvement in the KM community is to borrow techniques, processes, tools, methodologies, and applications from other disciplines and apply or adapt them to knowledge management (Liebowitz, 2000). For example, an important part of the knowledge audit process is to develop a knowledge map of sources, sinks, and flows of knowledge between individuals in an organisation.

2.4 Do KM frameworks use KM theory?

Knowledge management is a process of evolution and iteration to perform tasks by an individual or an organisation. There are some comments on knowledge management frameworks, (Liebowitz, 2001): (1) the framework should be both prescriptive and descriptive; (2) the organisational strategies and goals must be linked to knowledge management; (3) planning should occur before knowledge management activities are undertaken; (4) the cultural aspects of an organisation must be recognised and knowledge management must occur in a manner compatible with the culture of the organisation.

These frameworks should consider tools, technology, objective, intellectual capital and the culture of the organisation. Knowledge management includes activities such as acquiring, finding, selecting, verifying, storing, sharing and using knowledge. Explicit and tacit knowledge should be distinguished and used appropriately.

Table 2-1 provides different frameworks for the business world for tools, methods, practices and technologies available to knowledge management practitioners and explores a variety of application areas. These frameworks focus on and seek to improve performance of individuals and organisations by maintaining and leveraging

the present and future value of knowledge assets. Knowledge management encompasses people, their activities and their associated artefacts (Brian and Conrad, 1999). The important aspects of frameworks are the technologies, methods, and practices and their associated goals and approaches that target and resolve the problems. Some frameworks support classification to help individuals identify and differentiate among the roles different tools can play in a knowledge management system. Ruggles (1997) used a framework to identify and classify the individual elements of knowledge flows and their supporting knowledge management systems.

Most frameworks are conceptual models, for example (Ernst and Young, 1990) and (Skandia, 1999). They don't develop knowledge theory to implement and integrate ways of dealing with knowledge into business processes. Knowledge management should always constitute a good link to strategies that can be applied in the organisation and to its information. A generic knowledge model needs to determine strategies and apply them to knowledge management system. It also needs specific forms of knowledge management that may work in certain environments (organisations) and apply to business processes. These frameworks are not focused on the knowledge creation process as a dynamic human process.

It is important to differentiate between data, information and knowledge. Data is just facts and has no meaning unless one understands the context in which the data was gathered. Information is data that has been packed in a useful and understandable way. Knowledge is the richness of personal learning, insight and experience. Knowledge is the background that allows one to make the best decision. Knowledge can be in people's heads (tacit knowledge) or it can be written down or recorded (explicit knowledge). Knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder. There are two dimensions of knowledge (tacit and explicit) classified by Michael Polanyi (Polanyi, 1962). Drawing especially on Polanyi, Nonaka conceptualised knowledge in term of tacit knowledge and explicit knowledge. Tacit knowledge is personal, context-specific, and can be formalised and communicated. Explicit knowledge on the other hand, is transmittable in formal and language.

In an interview with Claus Otto Scharmer in Tokyo, Japan in February, 1996, Nonaka said that changing the context within the organisation is constrained by management.

However, the degree of friction of individuals and groups in setting their task boundaries is larger and more dynamic in the organization. Once the members of an urgent project team are approved by top management, they are empowered to do whatever is necessary to complete the project within the limited period of time. Also, they interact closely with top management. The roles and functions of top, middle, and lower management may rotate depending on the context within this compressed process of management. For example, a project leader may take the role of top management and a CEO can come below him or her, depending on the phase of the project (Scharmer, 1996).

The "knowledge creating company" describes how knowledge is created and transferred throughout an organization. In the theory of knowledge creation by Nonaka and co-author Takeuchi (Nonaka and Takeuchi, 1995), knowledge is seen as a dynamic human process of justifying personal beliefs as part of an aspiration for the "truth". Knowledge creation is a spiralling process of interactions between explicit and tacit knowledge. These interactions lead to the creation of new knowledge. The combination of the two categories makes it possible to conceptualise four conversion patterns. Nonaka also suggests different "Bas", a Japanese word with a special meaning of the concept of 'place', to address the question of fundamental conditions for knowledge creation which facilitate the knowledge conversion for his SECI Knowledge creation model (described earlier), which is the background theory of our research and is discussed further in the next section.

2.5 Importance of this Thesis

If knowledge management is to be of use in an organisation, it should be incorporated in daily business activities, such as a supply chain and its management especially for order processing, or negotiation, preparation of budget and on an operational level. Knowledge management needs to be integrated with these processes, which means that a system that supports business processes should also support knowledge management. We propose the methodology for integration of knowledge management into business processes and using software agents to facilitate this process is the contribution of research.

First, a knowledge model is proposed for the knowledge creation process that is based on Nonaka's knowledge creation process (Nonaka and Takeuchi, 1995). That model is then enhanced with concepts and a methodology is defined to integrate into business processes, using supply chain management as an example.

The proposed process is called the Evolving Knowledge Process (EKP) in this thesis. The EKP includes activities that create new knowledge within the business.

The second aspect is how to integrate the EKP into business processes. We call this the knowledge management process (KMP). Successful integration requires that selected knowledge management activities be initiated at appropriate points of the business process. This thesis describes a way to integrate these two kinds of processes. Organisations can use alternate strategies for such integration. They can centralise the knowledge process (KP) activities, distribute them, or have a mix of both.

The third aspect proposes software agents, which possess knowledge, to provide such support. The agents will contain the necessary knowledge to identify points in the process where knowledge should be processed and provide the tools to carry out the necessary knowledge management activities. We develop prototype to demonstrate their usefulness.

Software agents are autonomous pieces of software that sense their environment and take actions based on the environment conditions. Each EKP activity has its own agent, which will have the capabilities to find the right experts and to coordinate with other EKP activities and the other work-items. Other capabilities include:

- Notify participants to start a knowledge management activity,
- Provide tools to accomplish the activity,
- Find the knowledge objects needed in the EKP activity,
- Set up workspaces suitable for the EKP activity.

The fourth aspect uses a system known as LiveNet which has been developed at the Cooperative Systems Laboratory, University of Technology, Sydney (UTS) to realize the models. Each of the activities in the model becomes a workspace in the implementation. The user can create different folders in the workspace and each

folder contains the elements that contain the various knowledge object of the EKP process. They can also create work items and sub-workspaces. An authorised user can select documents and backgrounds, and get information about the various roles and participants in the workspace. Our prototype knowledge model can be implemented as a software agent to demonstrate the program.

2.5.1 Hypotheses of Research

1. How can knowledge management be integrated into business processes?
2. Is there any possible way to integrate knowledge management into business processes? By a proactive guide to the user to manage knowledge base?
3. How can an agent support and facilitate the integration of business process with knowledge management activities, rather than a separate knowledge process?
4. How can software agents be used to facilitate the integration of knowledge management into business processes?

These hypotheses will be discussed Chapter 4.

2.6 Outcomes of Research and Suggested Methodology in Practice

In this section, we develop our knowledge model which is based on Nonaka's model. The following will be the contribution of this research study to the area of knowledge creation process as well as to knowledge management in business processes. Figure 2-3 shows our research methodology in practice and our contribution.

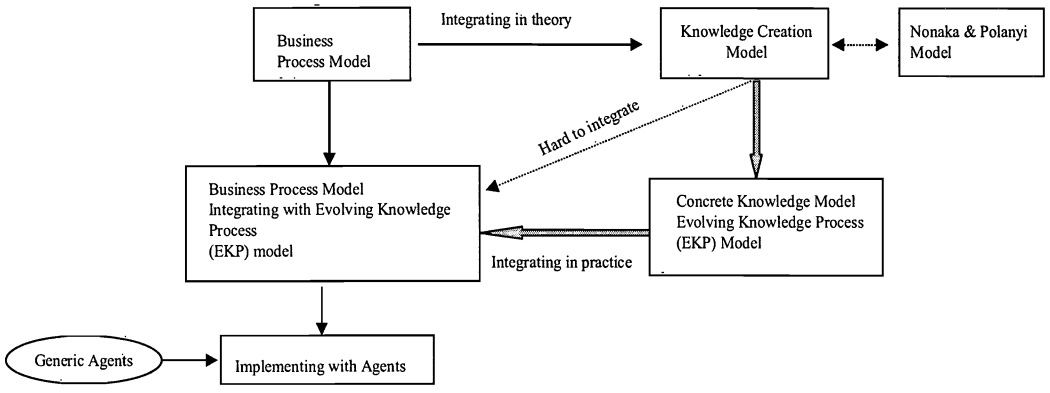

Figure 2-3 Research Methodology in practice

The model creation process described here follows a set of steps similar to those found in the Knowledge Chain (KC) model (Holsapple, 2003). The difference between the EKP model and the KC model lies in the integration of KM activities into the business process and in facilitating the process using software agents. The KC model identified nine distinct and generic KM activities. It identifies specific types of activities performed within each of the KM activities in the KC model. Practitioners will want to use these activities as a checklist when performing KM. For activities which are indicated by a high number of respondents as contributing to competitiveness, practitioners will realise that these are activities they will want to include in their KM initiatives. Holsapple's (2003) study will help to further substantiate the usefulness of the activities found in the KC model and help to build a portfolio of KM methodologies for organisation to utilise when performing KM. For example, how does performing these types of activities increase an individual employees' performance?

Our methodology also draws on the theoretical ideas of Nonaka and Takeuchi (1995) and Polanyi (1962) to provide a basis for the concrete knowledge model. The research provides a more precise definition of the knowledge management process to facilitate integration into business processes. We first define the knowledge process, here called the evolving knowledge process model that will be discussed more detail in Chapter 4.

We found that Nonaka's ideas were abstract and developed the EKP model as a realisation of the ideas in a concrete form made up of a number of steps that can be supported by agents. The EKP model is elaborated in detailed steps that can be integrated as activities or work items in a business processes. We describe the integration into business processes using a modified rich picture description (Hawryszkiewycz, 2000b).

Such integration emphasizes collaboration and we develop a metamodel that describes collaboration and can provide ways to include knowledge processing activities (Hawryszkiewycz, 2000b). Organisations can use alternate strategies for such integration. They can centralise the knowledge process (KP) activities, distribute them, or have a mix of both.

2.7 Summary

This chapter has provided a literature review of the different directions in knowledge management, knowledge management frameworks in business world, hypothesis of research, out come of research and suggestive methodology in practice.

There are many research directions in knowledge management in different areas, such as computer science, information systems, artificial intelligence, management science, cognitive sciences, psychology, linguistics, collaborative work processes, employee empowerment and knowledge ontology.

Research in knowledge management has different knowledge management frameworks and their goals. The goals of knowledge management frameworks are strategy, culture, characteristic of knowledge; organisational structure supports knowledge and performance. A KM framework means the various tools (methods, practice and technologies).

This chapter discusses Michael Polanyi's knowledge model and Nonaka's knowledge creation process as background theory in research. Even though Nonaka's model is more practical and applied in Japanese companies, it is more philosophical in concept. The research needs to develop a structured knowledge model to apply in business processes.

Finally, important steps of the thesis and hypothesis of research and suggestive methodology are discussed. There are many research directions and knowledge management frameworks in the business world, but few research studies show how to integrate knowledge management processes into business processes.

The following chapters make the connection between this research and hypothesis, methodology, proposed knowledge model and application in business processes and implementation.

Chapter 3

Methodology

This research proposes the integration of knowledge processes into business processes. It also discusses the use of agents that will facilitate the integration of knowledge management into the process. The role of a software agent is to ensure that a user's knowledge is used to best advantage in each stage of the business process. This chapter also describes agent-based technology as becoming popular in fulfilling the user's knowledge needs in an efficient manner.

In the following sections, this chapter describes the research objectives, research approach, methodology, research contribution and implementation of the model.

3.1 The Research Objectives

Depending upon lessons learned and the debacle of the 'new economy' enterprises, this chapter explains how knowledge management activities are seen by many as detracting from the main business activities and as such are often ignored or left till some free time becomes available. Alternatively, knowledge management activities are carried out independently of business activities (Maung, 2004a).

The key issues are why most knowledge management systems fail and how the risk of such failure may be minimised. There is much knowledge management research represented in business and academic areas, mainly in theory with little practice. Designing knowledge management systems should ensure that adaptation and innovation of business performance outcomes occurs in alignment with the changing dynamics of the business environment. Knowledge management research focuses on data, information technology, and human inputs that may be inadequate for effective business performance. These inputs cannot be used in practice; we should consider the influence of intervening and moderating variables such as motivation, inspiration, awareness, commitment and creativity, and innovation has to be better understood and accounted for in the design of knowledge models in business processes. The next step is the efficacy of inputs and how they are important issues in performance, and the

value of such performance outcomes may be challenges that need to be met for successful knowledge management.

Knowledge management systems can deliver the right information to the right person at the right time; the information flows will depend upon their accuracy and what can be shared across inter-enterprise boundaries. For example: in supply chain management, access to customer and supplier data residing in databases or networks that are hosted on the infrastructure of an outsourcing provider is particularly important in situations where sharing of proprietary strategic or competitive information about customer or supplier relationship needs to be safeguarded from third parties. Another consideration is that the tacit knowledge of executives and employees is important in the knowledge creation process. The role of customers, suppliers and partners includes their involvement in the business processes in production and services, and in helping each other out on shared concerns. It is important to note that such roles are assumed using their knowledge, skill and experiences in practice. Executives expect successful business performance outcomes and they realise that the next generation of knowledge management systems must be based on ongoing innovation of business value propositions and extended inter-enterprise value networks (Malhotra, 2004). Many of them want to know how investments in new knowledge management systems architectures and solutions would contribute to the adaptability of their business to the unprecedented and rapid pace of change.

Our research concentrates on two important activities. One is to define ways to capture and convert knowledge into forms useful within business processes (our example is supply chain management). The second is how to integrate the knowledge creation activities into the business processes. The research objective is to show how to concentrate on such integration and ways to model it. It also investigates how to define a knowledge creation process for knowledge management and it then describes expressing these activities in terms of business models such as the collaborative processes model (Hawryszkiewycz, 2000).

In terms of Curtis et al.'s classification, this model provides primarily functional and behavioural perspectives of the process model. The collaborative business process model is part of a methodology for the design of collaborative applications. Our

research defines a knowledge creation process for knowledge management based on Nonaka's knowledge creation process (Nonaka and Takeuchi, 1995) and proposes a way to integrate the KM process into business processes. It also suggests that software agents be used to facilities such integration. The next section discusses the detailed steps of the research.

3.2 Research Approach

Our research uses Nonaka' knowledge creation process as the theory for our methodology for knowledge management in the business environment. This framework contains elements and issues that are visible in recent contemporary research on knowledge management and organisational learning as means of creating a competitive advantage. In Nonaka's knowledge conversion process, new knowledge is created through a knowledge spiral where the key activities are socialisation, externalisation, combination and internalisation (SECI) through tacit knowledge made explicit in an iterative, spiral-like process (Nonaka, 1991; Nonaka *et al.,* 2000). Within an organisation SECI is a fundamental element of competence development and as such is the means for developing an organisation's knowledge assets. Knowledge needs a context to be created as it is context-specific. The context defines the participants and the nature of the participation. *Ba* is a place offering a shared context. The context is social, cultural, or organisational. Knowledge is created through the interactions among individuals or between individuals and their environment. We consider *Ba* as business processes in our research.

This research explores the means for knowledge management through the following steps, illustrated in Figure 3-1.

- First, we develop a concrete knowledge model and define knowledge activities and resources that occur in the knowledge creation process.
- We then show the completeness of the process by showing that it corresponds to Nonaka's process.
- We show how the concrete process can be integrated into business processes.
- We propose a framework for a methodology for integration of the knowledge creation process into business processes.

- This is followed by using agent support for knowledge management.
- Finally, we develop a software agent to be used to facilitate integration of knowledge management into business processes.

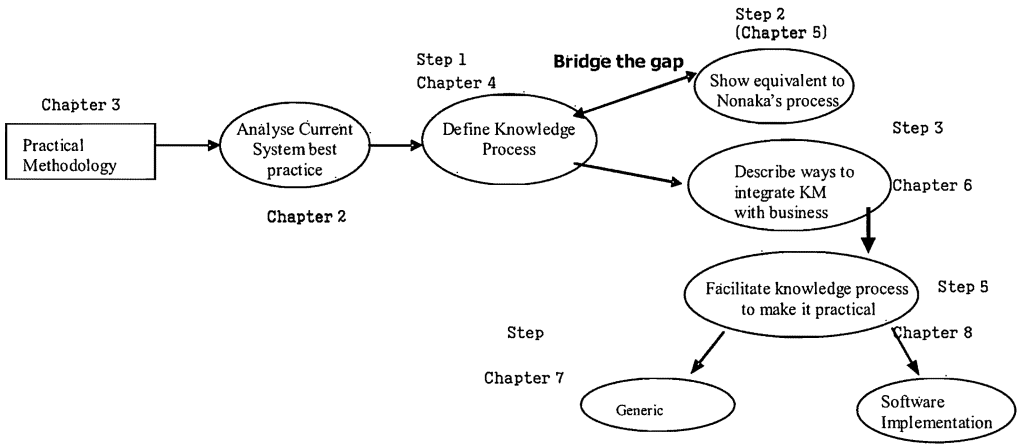

Figure 3.1 Explaining the research methodology

The research mainly sets out to demonstrate the knowledge creation process and the proposed concepts and methods in addressing the research problem. It shows more structured and detailed steps in the knowledge evolving process and how to integrate it into business processes. The argument is that this approach is more systematic than Nonaka's SECI stages but includes all of Nonaka's results. There is presently no such methodology in knowledge management research for systematically addressing the knowledge management research problem. Our research focus is to develop a concrete knowledge model and define a knowledge process to integrate into business processes and use agents to support knowledge management. The software agent is to be used to facilitate the integration of knowledge management into business processes. The background theory is based on Nonaka's knowledge creation process (Nonaka and Takeuchi, 1995) to develop knowledge model.

3.3 Defining the Methodology

Nonaka's model describes the way in which knowledge is converted from tacit to explicit and again to tacit through socialisation, externalisation, combination and internalisation (SECI) processes. However, there seems to be a lack of understanding

of how new knowledge is created in detail and research into the process of creating new knowledge has not been very strong (Buckley and Carter, 2000: Teece, 2000), in particular when new knowledge creation transcends ontological dimensions.

According to Nonaka's framework, the knowledge creation process consists of three elements: (i) the SECI knowledge conversion process; (ii) context knowledge, the *Ba*; and (iii) knowledge assets. All three are needed for new knowledge creation as they make up the inputs, outputs and moderator of the process. Leonard-Barton (1992) expresses the same thing using four distinct categories: (i) human knowledge and skills; (ii) technological skills; (iii) managerial systems; and (iv) values and norms. These are embodied and embedded in knowledge creation and controlled. Knowledge needs a physical context to be created. The conceptualisation of *Ba* is extended to cover the interdependent interaction between agents and structures. Thus *Ba* is a continuously created generative mechanism that explains the potentialities and tendencies that either hinder or stimulate knowledge creative activities (Nonaka and Toyama, 2003). *Ba* can emerge in individuals, working groups, project teams, informal circles, temporary meetings, virtual spaces such as e-mail groups, and at the front-line contact with the customer. *Ba* is an existential place where participants share their contexts and create new meanings through interactions.

Building knowledge assets within *Ba* (Context) we consider workspaces as business processes, for example supply chain management. Our argument is that Nonaka doesn't describe the integration of knowledge creation processes into business processes (*Ba*). A firm can be viewed as an organic configuration of various Bas, where people interact with each other and the environment based on the knowledge they have and the meaning they create, (Nonaka, 2003). However, Nonaka does not discuss detailed steps of knowledge creation in the context, only describes knowledge conversion.

Our research has found that there is a gap between theory and methodology in Nonaka's model. Our research proposes a way to integrate the knowledge creation process and business processes. Nonaka's model does not show how to integrate these two processes in practice. The model is abstract and only a philosophical approach in knowledge creation. We use Nonaka's model to develop our Evolving Knowledge

Process (EKP) model that is more concrete structured and detailed steps in knowledge creation process. This research discusses now an agent can interact with other agents in (workspace) business processes.

Here are the steps in our research and each step is discussed in more detail in the following chapters.

Step 1

Develop the evolving knowledge process model, which is based on Nonaka's knowledge creation process but uses practical ideas from current processes and practice. Here we have a suggestive methodology as the outcome of the research that is discussed in the following sections.

Step 2

In the evolving knowledge process model, activities are comparable to Nonaka's knowledge creation process in socialisation, externalisation, combination and internalisation (SECI). In this model, we define a sequence of activities and resources in the knowledge creation process. In this step, we show how the EKP model can be compared to Nonaka's process. We also show how the steps of Nonaka's process are distributed among the structured activities in Figure 5-1, Chapter 5. This is our challenge in research, to show an equivalent to Nonaka's knowledge creation process and that by implementing the process we will bridge the gap which we will discuss in Chapter 4.

Step 3

In this step, we integrate EKP activities into business processes and contribute to research in knowledge management in practice rather than theoretical issue. We have to clearly understand the business activities in the process then describe the work processes followed in each activity so that a person who performs task or duties can effectively use knowledge in business processes. Each activity needs to define the following processes and sources of knowledge and how it is captured in activity.

We have looked at other models of the business process. There are many different kinds of collaborative models in the business, learning environments, health, web-based systems and CSCW (Computer Support Collaborative Work) research areas. In

developing successful collaborative environments that satisfy their member's needs and improve collaboration within groups, it is advantageous to design some kind of user and group models describing, for example, the users' characteristics, roles, artefacts, workspace, and collaborative activities. One of the issues for collaboration and group models developed within knowledge management is that they need workspaces, assigned roles and collaborative activities. People are involved in a continuous collaborative process of knowledge construction in an environment that reflects the context in which that knowledge will be created in situation. The models of learning environments provide shared spaces for students to interact and comment on each other's work. Examples of collaborative models include CSILE by Brown (1994), the CoVis project Pea (1994), Mediated Collaborative Knowledge-Building in England (Crook, 1994), the WEB project in Vermont (Sherry, Billing, and Tavalin, 2000) and the collaborative learning and teaching (COLT) model (Hamada and Scott, 2000).

There are many important points to consider in the concept of the collaborative model.

- What types of characteristics should be involved in the model as objective indicators of collaboration between users (for example, role or level of participation)?
- How do we apply multi-user levels to enhance collaboration?
- How should we model the collaborative activities in business process in the collaborative environment?
- How do we pass information and messages to a particular forum? (For example, data, information.)
- What kinds of user activity can mediate the workspace?

These are critical considerations in the collaborative model. We use metamodel concepts (Hawryszkiewycz, 2000b) to describe the business processes and realise the integration by including EKP activities represented as these concepts. The metamodel concepts can be used to model collaborative processes. They use a representation based on methods adapted from Hawryszkiewycz that are used to represent business activities in a clear way. The major concepts are *activities*, *roles* and *artefacts*. Roles are assigned responsibilities in activities to create artefacts. Each activity is made up

of tasks carried out by people assigned to roles. Figure 3-2 uses the rich picture method to describe the major activities in business processes. The activities are represented by the *clouded objects*, the artefacts are represented by *rectangular boxes*, and links between participating roles and activities show the roles that participate in the activity. There are no arrows on the links between artefacts and the activities show the artefacts used in the activity. An *arrow* to an activity indicates that the activity only reads the artefacts. An arrow to the artefact states that the activity can change the artefacts.

Figure 3-2 shows a business process using the top level of activities for supply chain management in ordering and supplying items to the customers. Choosing a supplier and decision-making are activities represented as clouds. Current plans, knowledge resources, requirements and suppliers are artefacts in rectangular boxes. The manager, team member and customer are assigned to their activities (Maung, 2003b).

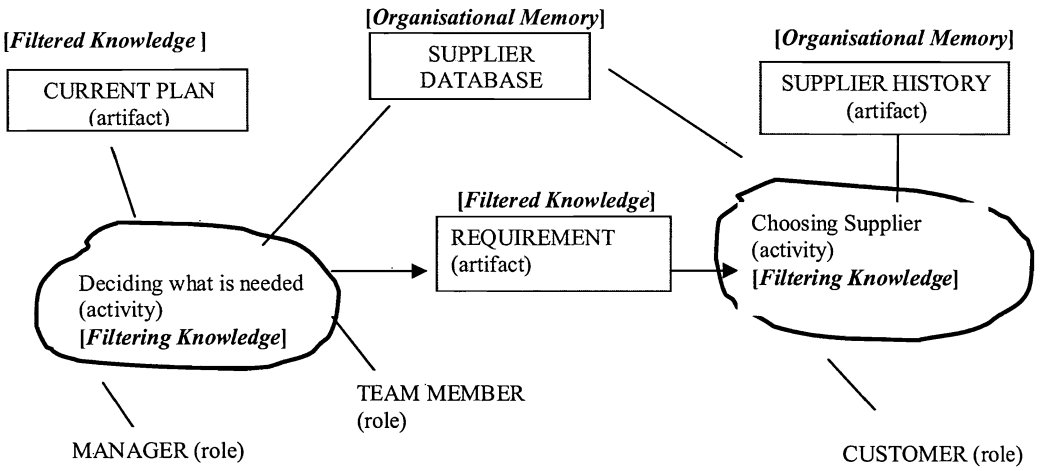

Figure 3-2 An Adapted Method to integrate the EKP model into the business process

Figure 3-3 illustrates integration of EKP model into business processes. All EKP activities and resources are described in italic letters in square brackets in rectangular boxes (artefacts) and clouds (activities). Details of the integration of the EKP model into business processes will be given in Chapter 6.

Step 4

This step is our challenge in knowledge management research. To facilitate the process we propose to define a *generic agent structure* and then apply our (EKP)

activities. The reason for defining the generic agent structure is to consider what types of agents interact and communicate with other agents directly and indirectly (Ferber, 2000) in EKP activities. The structure of the generic agent includes agent perception, agent knowledge about what information is needed in its activity, knowledge about the best sources of information needed for an activity and knowledge about the best ways to carry out an activity.

The research focused on agent perception is based on Nonaka's knowledge creation process and knowledge conversion (socialisation, externalisation, combination and internalisation), and we consider business processes as the *Ba* (workspace) where an agent can share with other agents in their context and create new meanings through their interactions. We define each agent to have a *goal*, *plan* and *activity* to perform their tasks in their context.

In this thesis, we consider Supply Chain Management as the *Ba* (workspace) as an example to show how EKP agents facilitate the business processes. More detailed discussion is given in Chapter 7.

Step 5

This step is the implementation using software agents that possess knowledge about their environment and can help users in that environment. We use the LiveNet collaborative system at the University of Technology, Sydney as the software agent to facilitate and integrate knowledge management into business processes. Details are discussed in Chapter 8.

3.4 Summary

This chapter has discussed the research objectives, research approach, contribution and methodology of the research. The methodology shows how to integrate knowledge management activities into business processes.

We also proposed agents, primarily to facilitate the integration of business processes with knowledge management activities, rather than for the actual processing of knowledge. The agents assist integration of these two processes.

Software agents possess knowledge about their environment and can help users in that environment. Implementation of the software agents will be described in Chapter 8.

The next chapter describes the Evolving Knowledge Process (EKP) Model that is based on Nonaka's knowledge creation process to develop a model for knowledge management.

Chapter 3

Methodology

This research proposes the integration of knowledge processes into business processes. It also discusses the use of agents that will facilitate the integration of knowledge management into the process. The role of a software agent is to ensure that a user's knowledge is used to best advantage in each stage of the business process. This chapter also describes agent-based technology as becoming popular in fulfilling the user's knowledge needs in an efficient manner.

In the following sections, this chapter describes the research objectives, research approach, methodology, research contribution and implementation of the model.

3.1 The Research Objectives

Depending upon lessons learned and the debacle of the 'new economy' enterprises, this chapter explains how knowledge management activities are seen by many as detracting from the main business activities and as such are often ignored or left till some free time becomes available. Alternatively, knowledge management activities are carried out independently of business activities (Maung, 2004a).

The key issues are why most knowledge management systems fail and how the risk of such failure may be minimised. There is much knowledge management research represented in business and academic areas, mainly in theory with little practice. Designing knowledge management systems should ensure that adaptation and innovation of business performance outcomes occurs in alignment with the changing dynamics of the business environment. Knowledge management research focuses on data, information technology, and human inputs that may be inadequate for effective business performance. These inputs cannot be used in practice; we should consider the influence of intervening and moderating variables such as motivation, inspiration, awareness, commitment and creativity, and innovation has to be better understood and accounted for in the design of knowledge models in business processes. The next step is the efficacy of inputs and how they are important issues in performance, and the

value of such performance outcomes may be challenges that need to be met for successful knowledge management.

Knowledge management systems can deliver the right information to the right person at the right time; the information flows will depend upon their accuracy and what can be shared across inter-enterprise boundaries. For example: in supply chain management, access to customer and supplier data residing in databases or networks that are hosted on the infrastructure of an outsourcing provider is particularly important in situations where sharing of proprietary strategic or competitive information about customer or supplier relationship needs to be safeguarded from third parties. Another consideration is that the tacit knowledge of executives and employees is important in the knowledge creation process. The role of customers, suppliers and partners includes their involvement in the business processes in production and services, and in helping each other out on shared concerns. It is important to note that such roles are assumed using their knowledge, skill and experiences in practice. Executives expect successful business performance outcomes and they realise that the next generation of knowledge management systems must be based on ongoing innovation of business value propositions and extended inter-enterprise value networks (Malhotra, 2004). Many of them want to know how investments in new knowledge management systems architectures and solutions would contribute to the adaptability of their business to the unprecedented and rapid pace of change.

Our research concentrates on two important activities. One is to define ways to capture and convert knowledge into forms useful within business processes (our example is supply chain management). The second is how to integrate the knowledge creation activities into the business processes. The research objective is to show how to concentrate on such integration and ways to model it. It also investigates how to define a knowledge creation process for knowledge management and it then describes expressing these activities in terms of business models such as the collaborative processes model (Hawryszkiewycz, 2000).

In terms of Curtis et al.'s classification, this model provides primarily functional and behavioural perspectives of the process model. The collaborative business process model is part of a methodology for the design of collaborative applications. Our

research defines a knowledge creation process for knowledge management based on Nonaka's knowledge creation process (Nonaka and Takeuchi, 1995) and proposes a way to integrate the KM process into business processes. It also suggests that software agents be used to facilities such integration. The next section discusses the detailed steps of the research.

3.2 Research Approach

Our research uses Nonaka' knowledge creation process as the theory for our methodology for knowledge management in the business environment. This framework contains elements and issues that are visible in recent contemporary research on knowledge management and organisational learning as means of creating a competitive advantage. In Nonaka's knowledge conversion process, new knowledge is created through a knowledge spiral where the key activities are socialisation, externalisation, combination and internalisation (SECI) through tacit knowledge made explicit in an iterative, spiral-like process (Nonaka, 1991; Nonaka *et al.,* 2000). Within an organisation SECI is a fundamental element of competence development and as such is the means for developing an organisation's knowledge assets. Knowledge needs a context to be created as it is context-specific. The context defines the participants and the nature of the participation. *Ba* is a place offering a shared context. The context is social, cultural, or organisational. Knowledge is created through the interactions among individuals or between individuals and their environment. We consider *Ba* as business processes in our research.

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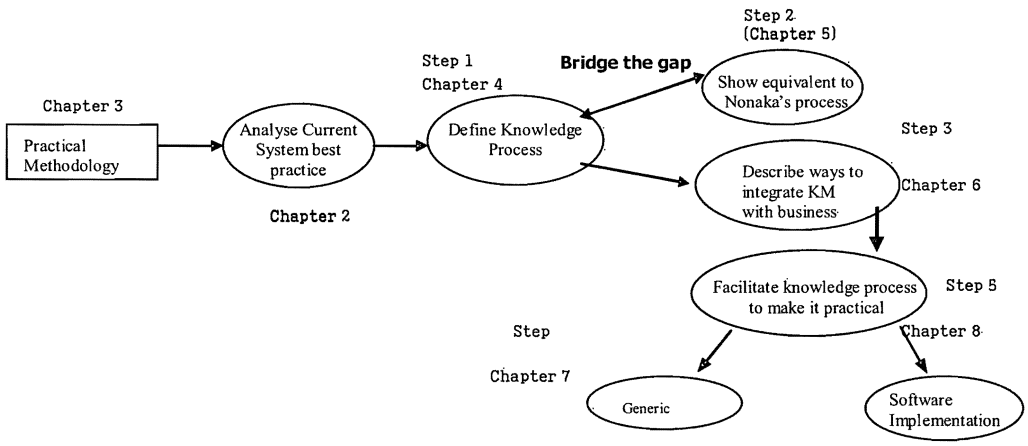

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Nonaka's model describes the way in which knowledge is converted from tacit to explicit and again to tacit through socialisation, externalisation, combination and internalisation (SECI) processes. However, there seems to be a lack of understanding

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Step 3

In this step, we integrate EKP activities into business processes and contribute to research in knowledge management in practice rather than theoretical issue. We have to clearly understand the business activities in the process then describe the work processes followed in each activity so that a person who performs task or duties can effectively use knowledge in business processes. Each activity needs to define the following processes and sources of knowledge and how it is captured in activity.

We have looked at other models of the business process. There are many different kinds of collaborative models in the business, learning environments, health, web-based systems and CSCW (Computer Support Collaborative Work) research areas. In

developing successful collaborative environments that satisfy their member's needs and improve collaboration within groups, it is advantageous to design some kind of user and group models describing, for example, the users' characteristics, roles, artefacts, workspace, and collaborative activities. One of the issues for collaboration and group models developed within knowledge management is that they need workspaces, assigned roles and collaborative activities. People are involved in a continuous collaborative process of knowledge construction in an environment that reflects the context in which that knowledge will be created in situation. The models of learning environments provide shared spaces for students to interact and comment on each other's work. Examples of collaborative models include CSILE by Brown (1994), the CoVis project Pea (1994), Mediated Collaborative Knowledge-Building in England (Crook, 1994), the WEB project in Vermont (Sherry, Billing, and Tavalin, 2000) and the collaborative learning and teaching (COLT) model (Hamada and Scott, 2000).

There are many important points to consider in the concept of the collaborative model.

- What types of characteristics should be involved in the model as objective indicators of collaboration between users (for example, role or level of participation)?
- How do we apply multi-user levels to enhance collaboration?
- How should we model the collaborative activities in business process in the collaborative environment?
- How do we pass information and messages to a particular forum? (For example, data, information.)
- What kinds of user activity can mediate the workspace?

These are critical considerations in the collaborative model. We use metamodel concepts (Hawryszkiewycz, 2000b) to describe the business processes and realise the integration by including EKP activities represented as these concepts. The metamodel concepts can be used to model collaborative processes. They use a representation based on methods adapted from Hawryszkiewycz that are used to represent business activities in a clear way. The major concepts are *activities*, *roles* and *artefacts*. Roles are assigned responsibilities in activities to create artefacts. Each activity is made up

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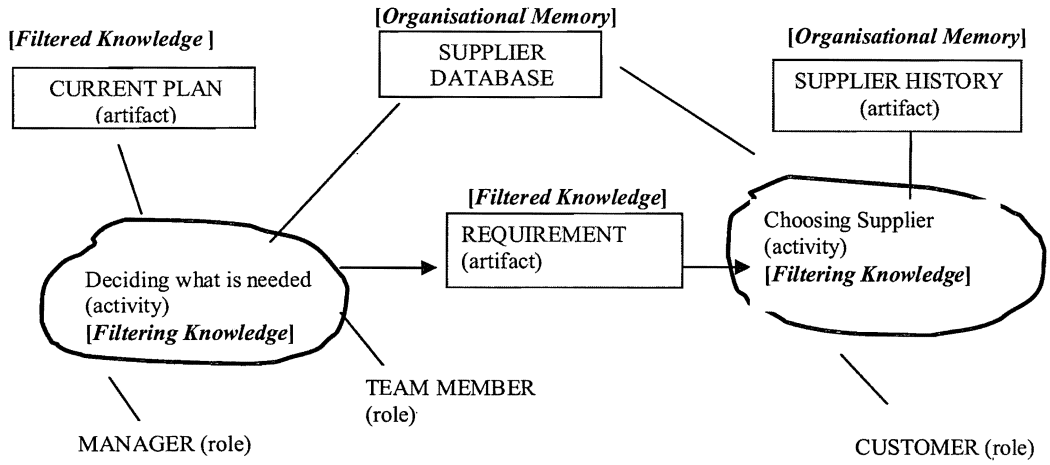


Figure 3-2 An Adapted Method to integrate the EKP model into the business process

Figure 3-3 illustrates integration of EKP model into business processes. All EKP activities and resources are described in italic letters in square brackets in rectangular boxes (artefacts) and clouds (activities). Details of the integration of the EKP model into business processes will be given in Chapter 6.

Step 4

This step is our challenge in knowledge management research. To facilitate the process we propose to define a *generic agent structure* and then apply our (EKP)

activities. The reason for defining the generic agent structure is to consider what types of agents interact and communicate with other agents directly and indirectly (Ferber, 2000) in EKP activities. The structure of the generic agent includes agent perception, agent knowledge about what information is needed in its activity, knowledge about the best sources of information needed for an activity and knowledge about the best ways to carry out an activity.

The research focused on agent perception is based on Nonaka's knowledge creation process and knowledge conversion (socialisation, externalisation, combination and internalisation), and we consider business processes as the *Ba* (workspace) where an agent can share with other agents in their context and create new meanings through their interactions. We define each agent to have a *goal*, *plan* and *activity* to perform their tasks in their context.

In this thesis, we consider Supply Chain Management as the *Ba* (workspace) as an example to show how EKP agents facilitate the business processes. More detailed discussion is given in Chapter 7.

Step 5

This step is the implementation using software agents that possess knowledge about their environment and can help users in that environment. We use the LiveNet collaborative system at the University of Technology, Sydney as the software agent to facilitate and integrate knowledge management into business processes. Details are discussed in Chapter 8.

3.4 Summary

This chapter has discussed the research objectives, research approach, contribution and methodology of the research. The methodology shows how to integrate knowledge management activities into business processes.

We also proposed agents, primarily to facilitate the integration of business processes with knowledge management activities, rather than for the actual processing of knowledge. The agents assist integration of these two processes.

Software agents possess knowledge about their environment and can help users in that environment. Implementation of the software agents will be described in Chapter 8.

The next chapter describes the Evolving Knowledge Process (EKP) Model that is based on Nonaka's knowledge creation process to develop a model for knowledge management.

Chapter 4

A Model for Knowledge Management

The previous chapter introduced the contribution made in this thesis and the methodology for integration of knowledge management processes into business processes. The present chapter defines the Evolving Knowledge Process (EKP) Model which is based on Nonaka's knowledge creation process and on our literature review of research in knowledge management frameworks and methodologies. EKP helps to develop a knowledge model in more detailed steps in knowledge creation activities.

This thesis argues that the EKP model is a concrete structure for the knowledge creation process that can be integrated into business processes and that software agents can be used to facilitate such integration.

In the following sections, we describe development of the EKP model from Nonaka's model. Our research finds the weak points and requirements of Nonaka's model and how to resolve them in EKP model. We also define and discuss each activity and the knowledge resources in EKP model.

4.1 The Concepts Behind the Evolving Knowledge Process (EKP) Model

Nonaka and Takeuchi (1995) drew on Michael Polanyi's (1966) distinction between *tacit* knowledge and *explicit* knowledge. Tacit knowledge is personal, context-specific, and therefore hard to formalise and communicate. Explicit, "codified" knowledge on the other hand, refers to knowledge that is transmissible in formal, systematic language. Polanyi contends that human beings acquire knowledge by actively creating and organising their own experiences. Thus, knowledge that can be expressed in words and numbers represents only the tip of the iceberg of the entire body of knowledge. As Polanyi (1966) puts it, "*We can know more than we can tell*" (p. 4). Polanyi contents that humans create knowledge by involving themselves with objects, that is, through self-involvement and commitment. To know something is to create its image or pattern by tacitly integrating particulars.

Some distinctions between tacit and explicit knowledge are shown in Table 4-1, (Nonaka and Takeuchi, 1995). Features generally associated with the more tacit aspects of knowledge are listed on the left, while the corresponding qualities related to explicit knowledge are shown on the right.

Tacit Knowledge (Subjective)	**Explicit Knowledge** (Objective)
Knowledge of experience (body)	Knowledge of rationality (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analogue knowledge (practice)	Digital knowledge (theory)

Table 4-1. Two Types of Knowledge (Nonaka, 1995)

For example, knowledge of experience tends to be tacit, physical, and subjective, while knowledge of rationality tends to be explicit, metaphysical, and objective. Tacit knowledge is created *here and now* in a specific, practical context and is *analogue* (Bateson, 1973). Sharing tacit knowledge between individuals through communication is an analogue process that requires a kind of *simultaneous processing* of the complexities of the issues shared by the individuals. On the other hand, explicit knowledge is about past events or objects *there and then* and is oriented toward a context-free theory. It is sequentially created by what Bateson calls *digital* activity.

Nonaka's dynamic model of knowledge creation is anchored to the critical assumption that human knowledge is created and expanded through social interaction between tacit knowledge and explicit knowledge. These two types of knowledge interact with and interchange into each other in the creative activities of human beings. Nonaka and Takeuchi call this interaction *knowledge conversion*. It should be noted that this conversion is a *social* process *between* individuals and is not confined *within* an individual. Knowledge is created through interaction between tacit and explicit knowledge; Nonaka and Takeuchi postulate four different modes of knowledge conversion: (1) from tacit knowledge to tacit knowledge, *Socialisation*; (2) from tacit

to explicit knowledge, *Externalisation*; (3) from explicit knowledge to explicit knowledge, *Combination*; (4) from explicit knowledge to tacit knowledge, *Internalisation*.

The objective of our research is to integrate knowledge management into business processes: what knowledge can be managed in organisations and how can knowledge be managed through the use of a knowledge process model?

There are many frameworks or methodologies in knowledge management research and the business world. Most researchers focus on the knowledge process and integrating KM into organisations. Knowledge management has to be linked with organisational goals and strategies. Knowledge management includes activities such as accumulating, searching, selecting, creating, retrieving and sharing knowledge and resources. We concentrate on the literature review and knowledge management frameworks in business world that were described in Chapter 2 to develop our knowledge process model. We base and focus on Nonaka's model and frameworks or methodologies in KM research to each EKP activity in our model.

Our model has six activities in the knowledge creation process: knowledge accumulation, domain knowledge analysis, filtering knowledge, knowledge interpretation, knowledge consolidation and knowledge refinement. Figure 4-1 illustrates the development of the EKP model. We consider what knowledge conversion mode of Nonaka's knowledge creation process is comparable to EKP activities, and what methodologies and frameworks occur in each EKP activity to develop the model. The EKP model has a more concrete structure and more detailed steps in the knowledge creation process than Nonaka's rather philosophical knowledge creation process.

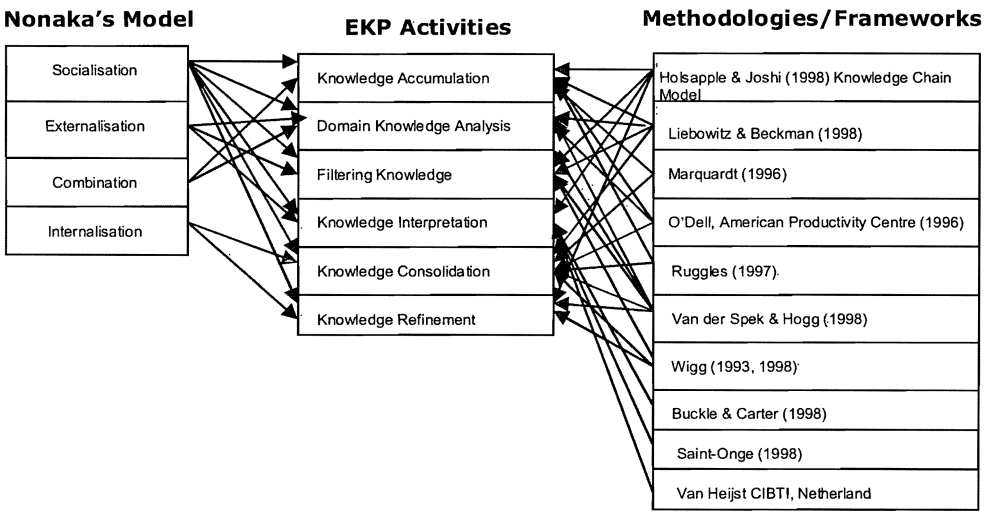


Figure 4-1. Development of the EKP model

(a) Knowledge Accumulation Activity

In the EKP model, knowledge accumulation consists of collecting and gathering information, data and knowledge by formal or informal methods, comparable to the socialisation mode of Nonaka's model. Alternatively in KM, frameworks such as the knowledge chain model of Holsapple and Joshi (1998) express this process as "Acquiring knowledge (including extracting interpreting and transferring)"; Liebowitz and Beckman (1998) as "Capture and secure knowledge"; Marquardt (1996) as "Acquisition"; O'Dell (1996) as "Collect"; Ruggles (1996) as "Generation (including acquisition and fusion)".

(b) Domain Knowledge Analysis

We identify domain knowledge analysis as identifying, classifying and organising captured knowledge in the EKP model. Domain knowledge analysis is comparable to socialisation, externalisation, and combination in Nonaka's model. We find similar approaches in other frameworks and methodologies: Liebowitz and Beckman (1998) "Identify and verify knowledge"; O'Dell (1996) "Identify"; and Van der Spek and de Hoog (1998) "Combining available knowledge" or "Conceptualise (including make an inventory of existing knowledge and analyse strong and weak points".

(c) Filtering Knowledge

Filtering knowledge describes determining whether the knowledge is relevant to a particular goal, and retaining it if relevant, otherwise reject it (Godbout, 1996) in the EKP model. Filtering knowledge occurs in Nonaka's knowledge creation process as socialisation and externalisation. Other approaches include: Holsapple and Joshi (1998) "Selecting knowledge (including locating, retrieving, and transferring)"; Liebowitz and Beckman (1998) " Transform information into knowledge", " Organise knowledge"; Van der Spek and de Hoog (1998) "Review (including compare old and new situations and evaluate achieved results)"; and Wigg (1993) " Value realisation".

(d) Knowledge Interpretation

Nonaka and Takeuchi define knowledge interpretation: "It is a dynamic human process of justifying personal belief toward the *truth*", (Nonaka and Takeuchi, 1995) in their well-known book *the Knowledge Creating Company*. We identify knowledge interpretation in the EKP model as determining the value provided by filtered knowledge. This activity can be compared to other frameworks: Buckle and Carter (1998) "Knowledge transfer method"; Holsapple and Joshi (1998) "Internalising knowledge (including assessing, targeting and depositing)", " Using knowledge" and "Externalising knowledge (including targeting, producing and transferring)"; Wigg (1998) from the knowledge research institute describes "leverage existing knowledge" and "deploy knowledge"; Marquardt (1996) "transfer and utilisation"; Saint-Onge (1998) "Learn (tacit development)", "Transfer" and "Act (developing capability through values deployment)"; O'Dell (1996) "Apply" and "Create"; Wigg (1993) "Dissemination application".

(e) Knowledge Consolidation

Knowledge consolidation in the EKP model consists of classifying interpretative knowledge about which events are related to the categories and what are the main interesting objects. It occurs in the combination and internalisation stages of Nonaka's process. We consider this activity to compare with: Holsapple and Joshi (1998) "internalising knowledge (including assessing, targeting and depositing) and externalising knowledge (including targeting, producing and transferring)"; Knowledge Associate (Young, 1999) "develop and retain"; Wigg (1998) "store

knowledge"; Liebowtiz (1998) "combine knowledge"; Marquardt (1996) "storage"; O'Dell (1996) "organise"; Skandia (1999) "intellectual capital development box"; Van der Spek and de Hoog (1997) "combining available knowledge"; Van Heijst , "consolidation (storing individual knowledge, evaluation and indexing"; "combination (combining disparate information and increasing access to distributed data)".

(f) Knowledge Refinement

We express knowledge refinement as modifying and updating knowledge into a form suitable for use in business activities. The socialisation mode of Nonaka's knowledge creation process can be compared to the knowledge refinement activity in the EKP model. Some examples in KM frameworks are: Holsapple and Joshi (1998) "generating knowledge (including monitoring, evaluating, producing and transferring)"; Van der Spek and de Hoog (1997, 1998) "reflect (including decide on required improvements and make plans to improve process)", "act (including secure knowledge and develop knowledge)", "review (including compare old and new situation and evaluate achieved results)"; and Wigg (1993) "value realisation".

4.2 Why we define EKP activities and resources?

In this section, we discuss the reasons for defining the six activities and resources in the EKP model described in the preceding section.

The first step is the ***Knowledge Accumulation*** activity in the EKP model. Before knowledge is created, we need to collect and gather useful information, data and knowledge that is required by an individual or organisation. In this activity, we need to consider that *Ba* (Nonaka and Kono, 1998) describes the existential contexts that can be thought of as a shared mental place for emerging relationships. This place can be physical (for example, an office or a dispersed business place), virtual (such as e-mail, teleconferencing, web chat room) or mental (shared experiences, ideas, ideals). *Ba* provides a platform for interaction between individual and/or collective knowledge. Thus, in knowledge creation *Ba* is the first important issue to consider when accumulating knowledge in formal or informal ways.

This activity is similar to the first step of the "Knowledge Chain Model" (Holsapple and Joshi, 1997) "Acquiring knowledge", (Ernst and Young, 1999), Knowledge Associate (Young, 1999) (refer to Table 2-1 knowledge management framework).

After knowledge is accumulated, we acquire ***Captured Knowledge*** with goals and plans for a particular activity by an individual and/or organisation. This knowledge may be either tacit or explicit or both; it enables the utilisation of the knowledge.

For example. in supply chain management, a manager finds out supplier information and data about products and services that the customer needs and wants through virtual spaces and business meetings.

The next step in the EKP model is the ***Domain Knowledge Analysis*** activity, which identifies, organises and classifies (***Captured Knowledge***) and records the results as (***Utilisable Knowledge***) as the competitive environment changes (Holsapple and Joshi, 1997), (Liebowitz and Beckman, 1998), (Liebowitz, J and Rubenstein-Montano, 2001), (Ruggles, 1997). Domain knowledge analysis can be described as a set of models that describe various properties and behaviours within a domain. Knowledge may be recorded in an individual brain or stored in documents, organisational processes, products, services, facilities or systems. This knowledge is derived from the process which analyses the given set of tacit and explicit knowledge based on predefined domains, rules and norms. It is the first acquired prerequisite knowledge of the business domain and is the basic know-how of the business and its transformation of methods into activities that are relevant in the specific context of the business domain. It is further used in analysing the particular application. Domain knowledge analysis is specific to the entity that created it and thus is the familiarity, awareness or understanding through experience, skill, and learning also encompassed in the term "Expert Knowledge". The person's knowledge is derived from experience, skill and knowledge in interacting with the environment, and is expressed in formal ways (documents, procedures, rules and regulations) and in informal ways (story-telling, observations) (Maung, 2003b).

For example, a website developer has expert knowledge in Java programming.

An important step in the EKP model is ***Filtering Knowledge***, which determines whether knowledge is relevant to a particular goal. If it is relevant then it is stored until it is needed; otherwise it is ignored (Godbout, 1996). Knowledge has to be filtered before being processed because we need relevant knowledge; otherwise the knowledge has to be rejected. Filtering knowledge transforms information into useful and relevant knowledge, and puts it in the grasp of those in need. (Van Heijst and Kruizinga, 1997) describe as development creating new ideas, analysing failures and examining current experiences. (Steiner and Huffman, 1997) in the Price Waterhouse Coopers framework describe this step as "find and then filter (for relevance)".

After the filtering knowledge process, ***Filtered Knowledge*** can be interpreted in ***Knowledge Interpretation*** to determine the value of the knowledge, including possible ways it can be applied in making decisions in the current environment or ongoing organisation. The person *knows how* and *knows what* to interpret to understand and create selected or desired knowledge (***Filtered Knowledge***) to make decisions and take actions that result in effects and outcomes (Maung 2003b). Van der Spek and de Hoog (1998) addressed their model as: reflect (including decide on required improvement and make plans to improve the process), act (including secure knowledge and develop knowledge), review (including compare old and new situation and evaluate achieved results).

EKP carries on the ***Interpretative Knowledge*** to the ***Knowledge Consolidation*** activity to classify interpretative knowledge and events relating to the categories which are known or have been encountered before (in the knowledge consolidation stage), while recognising the identities and main attributes of interest. Marquardt (1996) addressed this stage as transfer and utilise, then store; Young (1999) addressed this stage as develop and then retain the information. Wigg (1998) describes in his framework the capture and storage of knowledge, then organising and transforming it.

The last activity of EKP is ***Knowledge Refinement***, a process of modifying or updating knowledge into an appropriate form for use in activities and storing it as ***Organisational Memory*** for short-term or long-term memory. Alle (1997) describes this step as renewing after optimising knowledge; Wigg (1993) describes it as value realisation in his framework.

Our model has six activities in the knowledge creation process and each activity produces knowledge resources. These activities are not simply unidirectional in the process; some of them are bi-directional. Nonaka only addresses tacit and explicit knowledge in his knowledge creation process but does not discuss how knowledge is created in each mode. Each activity in the EKP model is comparable to Nonaka's process and also we consider *Ba* (Context) where *Ba* is not simply a physical space but equally a mental space and an interaction space facilitating individual and organisational absorptive capacity. *Ba* is a necessity for creating a common purpose to create knowledge.

We argue that the EKP model is more concrete and has more detailed steps than Nonaka's knowledge creation process. In the following section, we will describe the EKP model in more detail.

4.3 The Evolving Knowledge Process (EKP) Model

The Evolving Knowledge Process (EKP) model has been described earlier (Maung, 2003a) and uses Nonaka's idea as the underlying structure. It is similar to Holsapple's (2003) Knowledge Chain Model that has been described in the methodology section in Chapter 3 and the process of knowledge creation and innovation (Soo, and Midgle, et al, 1999) but differs in the way that knowledge management activities are integrated into business processes.

The process of knowledge creation and innovation (Soo, and Midgle, et al, 1999) provides a general and specific look at a firm's knowledge systems and the impact that they have on the ability of the organisation to generate innovation and financial performance from these underlying subsystems. Their research focuses on relationship between networking, knowledge creation, innovation and financial and market performance. In their model, three components are ***Sources*** (formal and informal networking), ***Uses*** (quality of problem solving/decision making) and ***Outcomes*** (innovation and market/financial performance). First, there must be ***sources of information and know-how*** on which an individuals' knowledge base is built. These sources arise from internal and external network opportunities to generate and utilise a knowledge base. Second, the organisation and individual must have ***absorptive capacities*** for internalising and integrating the information and know-how

being extracted from the network of contacts and sources. Third, because knowledge is ***actionable***, it must be created through applications. They look at whether information and knowledge is utilised to generate higher levels of comprehensiveness (more thorough analysis of options), creativity (application of novel solutions), consensus (shared commitment to implement chosen options) and new knowledge (new ideas, insights, better problem solving processes and new ways of thinking) in decision making.

In the Evolving Knowledge Process (EKP) model, we choose knowledge management activities to establish goals and arrange plans for each activity in the knowledge creation process. Knowledge creation is conceptualised as a dialectical process in which various contradictions are synthesised through dynamic interactions between individuals, the organisation, and the environment. With the view of a firm as a dialectic, strategy and organisation should be re-examined as synthesising and self transcending processes instead of a logical analysis of structure or action (Nonaka and Toyama, 2003). In knowledge creation, one cannot be free from one's own context. Social, cultural, and historical contexts are important for individuals (Vygotsky, 1986) because such contexts give the basis for interpreting information to create meaning. Therefore personal knowledge can lead to fallacies because of limited environmental interaction and externalisation and the whole complexity of the given phenomenon may remain undiscovered.

The EKP process model is defined as a sequence of activities that create and capture knowledge in a business context. As shown in Figure 4-2, the process consists of activities and resources.

(a) **Knowledge Activities:** *knowledge accumulation, domain knowledge analysis, filtering knowledge, knowledge interpretation, knowledge consolidation and knowledge refinement.*
(b) **Knowledge Resources:** *captured knowledge, filtered knowledge, utilised knowledge, interpretative knowledge, consolidated knowledge and organisational memory.*

The challenge of the EKP model is to show more detailed steps of the knowledge creation process. It consists of six knowledge activities that are distributed in Nonaka's (SECI) model described in Section 3.4 and Figure 3-2.

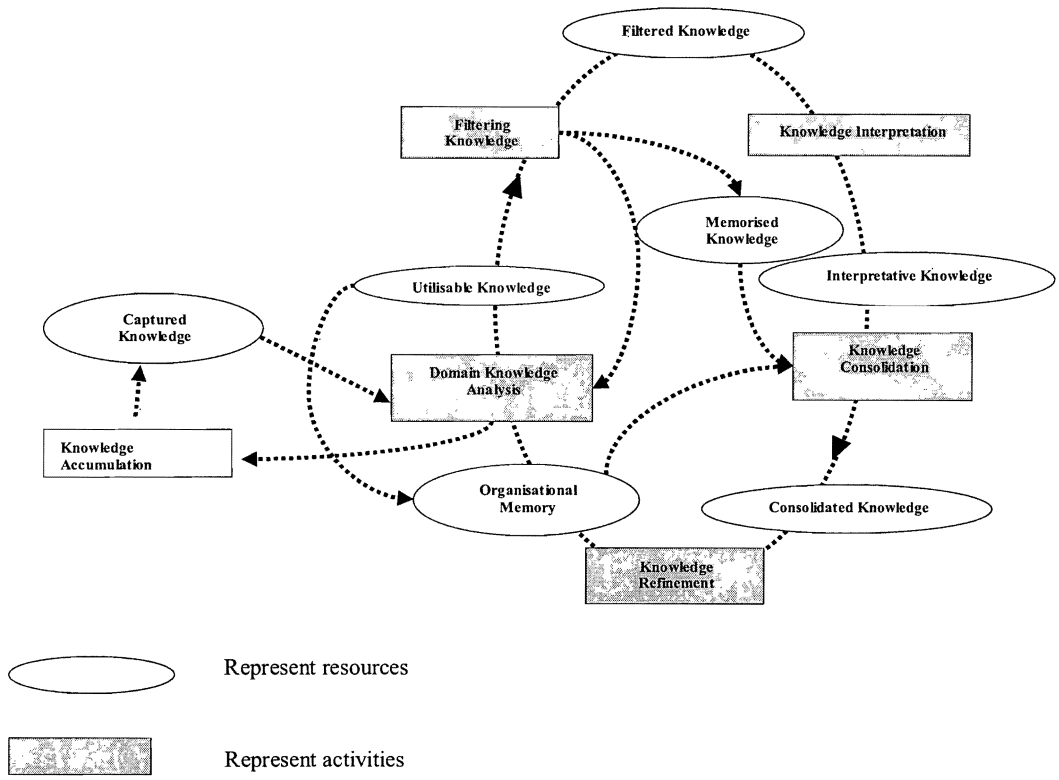


Figure 4-2. Evolving Knowledge Process (EKP) Model

Figure 4-2 illustrates our model to show how the six knowledge activities evolve in the knowledge creation process. We found that knowledge creation is not a linear process but is a spiral process.

4.4 Summary

In this chapter, we describe how our Evolving Knowledge Process Model is made of a more concrete and structured knowledge creation process than Nonaka's. The chapter explains the concepts of the EKP model, which is based on Nonaka's knowledge creation process and frameworks in KM research.

The chapter also explains all the detailed processes of the EKP model. Our EKP model has six knowledge activities: knowledge accumulation, domain knowledge analysis, filtering knowledge, knowledge interpretation, knowledge consolidation and

knowledge refinement. Knowledge resources are captured knowledge, filtered knowledge, memorised knowledge, interpretative knowledge, consolidated knowledge and organisational memory.

With a concrete knowledge process model, there will be problems for the knowledge creation process in which agents can support the process. Knowledge creation needs agents to perform actions and make decisions. These are undertaken by agents: people, organisations or technology. Agents carry out all the actions and exhibit all the behaviour within the process. We define a generic agent structure and EKP agents that support all activities in the evolving knowledge process in Chapter 7 to facilitate the process.

Chapter 5

Comparison of the EKP Model and Nonaka's Model

The previous chapter described the concepts and development of our EKP model which is based on Nonaka's knowledge creation process. In this chapter, we compare the EKP model and Nonaka's model.

We argue that the activities of the EKP model are distributed in each knowledge conversion mode of Nonaka's process and each activity of the EKP model is more concrete and organized than the basic model. In the following sections, we discuss how Nonaka's SECI modes appear in the EKP model and then compare EKP activities and Nonaka's SECI modes.

5.1 Nonaka's SECI modes are distributed in the EKP Model

Figure 5.1 shows how Nonaka's SECI modes are distributed in the EKP model and Table 5-1 explains how EKP activities are comparable to Nonaka's knowledge creation process. Some EKP activities are not found in Nonaka's SECI model.

The ***Socialisation*** mode is applicable in the EKP activities of knowledge accumulation, domain knowledge analysis, filtering knowledge and knowledge interpretation. Socialisation means finding a way to share the knowledge that exists only in minds and imaginations; it is critical to the success of objectives and goals of organisation.

Example: People telling their stories are very useful in sharing information. Thus, stories are another information source, and people can draw on common understood truths to convey more information than is obvious. We can consider stories in terms of experience with knowledge and information that engage the people as listeners or readers.

Externalisation occurs in the domain knowledge analysis, filtering knowledge and knowledge interpretation activities of the EKP model. The externalisation mode of knowledge conversion is typically seen in the process of concept creation and is triggered by dialogue or collective reflection (Nonaka and Takeuchi, 1995).

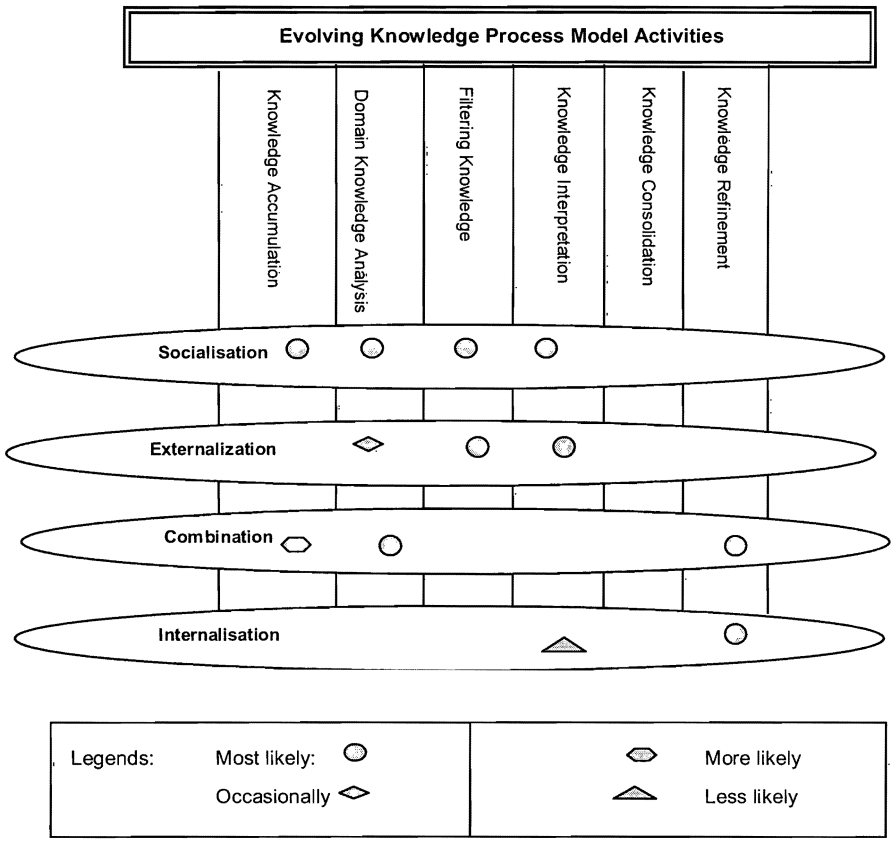


Figure 5-1 Nonaka's model is distributed within EKP activities

Example: The case of Canon's Mini-Copier (Nonaka and Takeuchi, 1995) is a good example of effective product development. In this case study, one of the most difficult problems faced by the development team was producing at low cost a disposable cartridge, which would eliminate the necessity for the maintenance required in conventional machines. At that time, there were no personal copiers in homes because drums were very expensive. The objective of the team was to produce a copier for family or personal use at a cost low enough to be consistent with the targeted low selling price of the copier. Later they took an idea from disposable beer cans and discovered a process technology to manufacture the aluminium drum at low cost, thus inventing the disposable drum.

Combination happens in three activities of the EKP model: knowledge accumulation, domain knowledge analysis and knowledge refinement. This mode of knowledge conversion involves combining different bodies of explicit knowledge.

Example: At the top management level of an organisation, the combination mode is realised when mid-range concepts (such as product concepts) are combined with and integrated into a grand concept (such as corporate vision) to generate new ideas and concepts for products or services.

Internalisation applies in the knowledge interpretation and knowledge refinement activities of the EKP model. This process embodies explicit knowledge in tacit knowledge and an alternative way to describe it is as "learning by doing" (Nonaka and Takeuchi, 1995).

Example: The Honda City case study in Japan (Nonaka and Takeuchi, 1995). All the members of the Honda company internalised their experiences of the late 1970s and are now making use of that *know-how* and leading R&D projects in the company. For organisational knowledge creation to take place, however, the tacit knowledge accumulated at the individual level needs to be socialised with other organisational members, thereby starting a new spiral of knowledge creation.

5.2 Evolving Knowledge is Comparable to Nonaka's Knowledge Creation Process

We describe how our EKP activities are comparable to Nonaka's knowledge creation process in Table 5-1.

EKP Activities	**Socialisation** *Thinking it, then doing it* (Tacit to Tacit)	**Externalisation** *Doing it, then describing it* (Tacit to Explicit)	**Combination** *Finding it, then combining it* (Explicit to Explicit)	**Internalisation** *Trying it, then believing it* (Explicit to Tacit)
Knowledge Accumulation	Informal way of observation and finding information.	Not generally applicable.	Reconfiguration of existing information. Look at similar objects and combine.	Not generally applicable.
Domain Knowledge Analysis	Mapping of knowledge to facilitate the availability of documents, information, data and social network.	Analyzing, classifying, categorising and identifying captured knowledge.	Combining with existing utilisable knowledge.	Not generally applicable.

Filtering Knowledge	Discussing and/or meeting to consider the value of utilisable knowledge.	Searching for related metaphors, models, ideas and concepts to create new knowledge.	Not generally applicable.	Not generally applicable.
Knowledge Interpretation	Sharing knowledge to consider whether interpretative knowledge will be used in making decisions.	Considering knowledge against models, concepts and ideas to access effectively.	Not generally applicable.	Learning by doing in practice to gain new knowledge, concepts and ideas.
Knowledge Refinement	Modify and update existing knowledge through dialogue.	Not generally applicable.	Modify and update existing rules and regulations and existing knowledge.	Not generally applicable.

Table 5-1. EKP activities are comparable to Nonaka's knowledge creation process

5.3 Summary

This chapter has shown how the activities of EKP model are related to the knowledge conversion modes of Nonaka's knowledge creation process.

In the next chapter, we will discuss a method of integration of EKP activities into business processes.

Chapter 6

A Method for Integration into Business Processes

6.1 Knowledge Intensive Processes in Organisations

This chapter describes our methodology for integrating the EKP model into business processes. Firstly, we explain that the goal of most organisations is to use their information resources in effective ways to identify new products and services. Many are using the world wide web on the internet. In the past, most organisations used the internet as a place to apply for contact exchange information. Now they are looking for new ways to share knowledge. Hawryszkiewycz (2000a) exlains that most enterprises are looking at ways to gain benefit from the information capital in their intranet sites by evolving knowledge sharing with other enterprises. Enterprise workgroups can be formed to combine the explicitly stored knowledge in intranets and use their tacit knowledge to develop new knowledge. These communities can evolve from relatively informal exchanges to focused knowledge sharing processes with identified goals, agreed governance structures and supported by knowledge sharing tools.

Secondly, we explain the generic activities in knowledge creation and their collaborative nature. We describe approaches to models and systems, and then describe a metamodel in Figure 6-10 for their description. We also describe how the semantics of the metamodel can be supported using information technology, concentrating on the support of distributed communities in organisational settings. We use metamodel concepts (Hawryszkiewycz, 2000b) to describe the business process and realise the integration by including EKP activities represented as these concepts.

Finally, we review different kinds of existing models for collaborative processes and select a suitable model for this research. We use two examples (a) Supply Chain Management and (b) Online Learning, to illustrate the models for integrating EKP activities into business processes.

6.2 Review of Existing Models for Collaborative Processes

In this section, we discuss different models that can describe work environments for knowledge management processes. Selecting a model is a very important part of our research. A great many models can be applied in different research directions. The intention of this section is not to comprehensively review all of these models. Different models often need different kinds of work practice. This section concentrates on the process of developing models while describing their relationships to the other processes. As discussed in Chapter 3, one of our research objectives is to describe ways to integrate knowledge management into business processes. Thus, we consider a suitable and reliable model that suits our research objectives and can combine organisational structures and social structures. In the following sections, we describe different models and select a metamodel for collaborative processes (Hawryszkiewycz, 1998) that can be applied to the knowledge management process.

6.2.1 Data flow diagram models

Data flow diagram models use a number of symbols to represent systems. Most data flow modelling methods use four kinds of symbols to represent four kinds of system components: processes, data stores, data flows and external entities. Data flow diagramming can represent a system at any level of detail with a graphic network of symbols showing data flows, data stores, data processes, and data sources and destinations. The diagrams are logical representations, graphical, and hierarchical, to show the different levels. The objective of data flow diagramming is to show the common understanding of a model of a system. Data flow diagrams show the transformation or changing of data in an input, process, output format.

We will now illustrate a data flow diagram model to describe a nonpredefined process in Figure 6-1. A purchasing department buys many different types of items from many suppliers. When purchase requests arrive in the purchasing department, they record customer information in the customer database and find out what items are to be ordered. As soon as a need has been identified and precisely described, the purchasing department purchases items from suppliers and arranges for delivery to customers. The illustration shows the basic processes of the customer order, finding suppliers and delivering items to the customer.

The use of data flow diagrams as modelling tools was popularised by DeMarco (1978) and Gane and Sarson (1979) through their structured systems analysis and design methodologies. Their suggestion is that a data flow diagram should be the first tool used by systems analyst to model system components.

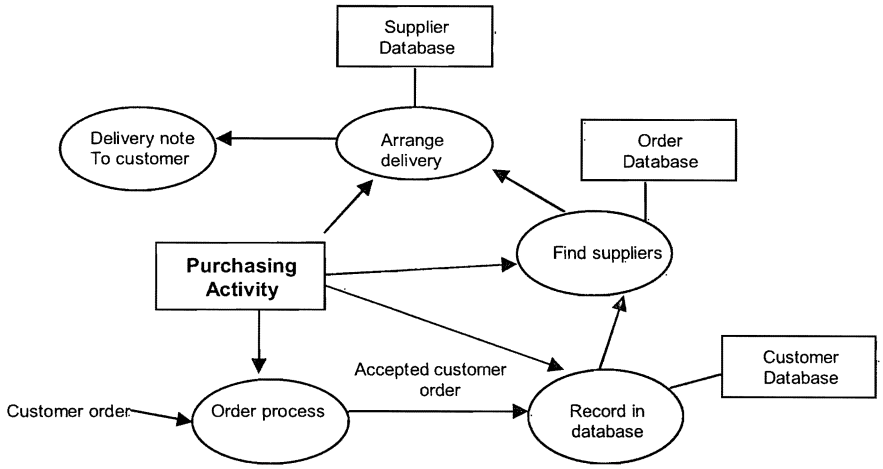


Figure 6-1. Data flow diagram model

Figure 6-1 illustrates the data flow diagram for the purchasing process for customer orders and delivering items. Developing a knowledge model requires a number of stages in which certain activities need to be carried out. Knowledge processing involves the identification of techniques to acquire, store, process and distribute information. Top management should be approached with facts about the costs and benefits of knowledge management systems. Knowledge management concerns capturing knowledge by extracting, analysing and interpreting the relevant knowledge that a human expert uses to solve a specific problem. In KM systems development, the knowledge developer acquires the necessary heuristic knowledge from the experts to build the appropriate knowledge base.

Our research finds that there is no knowledge management in such a model to integrate EKP activities. Data Flow Diagramming can be described graphically and logically characterize data processes and flows in a business system (basically, inputs, processes, and outputs) and only flow of data within the system.

6.2.2 Entity-Relationship (E-R) Model

Entity-Relationship (E-R) analysis uses three major abstractions to describe data. These are:

- *entities*, which are distinct things in the enterprise;
- *relationships*, which are meaningful interactions between the objects; and
- *attributes*, which are the properties of the entities and relationships.

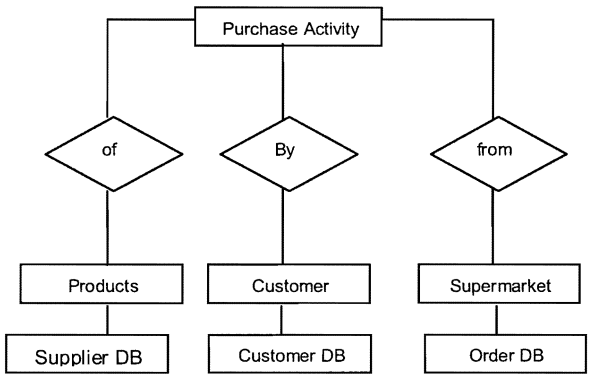


Figure 6-2. E-R Model

Figure 6-2 illustrates the simplest E-R construct. Each entity set in the E-R diagram can be linked to more that one relationship set. The purchase entity set is associated with the three entity sets products, customer and super market.

There are some important points to consider here: how to choose entities, relationships and attributes; how to choose names; and what steps should be followed in analysis. The most common system entities are distinct physical things in the organisation, such as people, parts, projects and invoices. the E-R model is then refined by converting it to a relational model. The relational model provides a number of criteria to construct normal-form relations. Most E-R and relational model are used in database design.

Applying an E-R model requires a knowledge management process. There is no way to apply knowledge management in an E-R model. Knowledge management is about people and the way they creatively perform in an environment conducive to knowledge. "People" are the knowledge workers: managers, customers and suppliersin an organisation. They must be studied to understand existing knowledge exchanges that the organisation uses and to find ways to capture knowledge.

Knowledge management systems can assist changes in market demands, customer tastes and preferences of products and services. Knowledge management can identify information through the users' observation or experience. There are several sources of knowledge that drive organisations:

- *Customer knowledge*: their needs, who to contact, customer buying power.
- *Product knowledge*: the products in the market place, who is buying them, what prices they are selling at and available purchase prices.
- *Financial knowledge*: capital resources, where to acquire capital and at what cost, and the integration of financial practices.
- *Personnel practices knowledge*: the expertise available, the quality services they provide, and how to go about finding experts, especially in customer service.

Knowledge management is intellectual capital that represents the value of a company's trademarks, patents, or brand names.

Developing a knowledge model requires capturing both tacit and explicit knowledge. An E-R model is not useful for the knowledge management process. It does not support the process. It is only a relational model to show relationships between entities and attributes.

6.2.3 Object Modelling

The object oriented approach differs from structured systems analysis and design because it provides a way of modelling that integrates data and processes. Thus, rather than modelling systems by data flows, E-R diagrams or process description models, all three components are integrated together into objects.

An object model is usually made up of many objects related to each other. Such relationships are shown by references between the objects. A reference to an object is usually made through an object property, as illustrated in Figure 6-3.

This model shows the relations of objects that integrate data and processes. Using the idea of an object that represents a business process is only one approach to modelling systems. For example: The link from the supplier company to a customer order is

Item No: PBM 12547 and the task is to issue a receipt and deliver to customer and then update customer information.

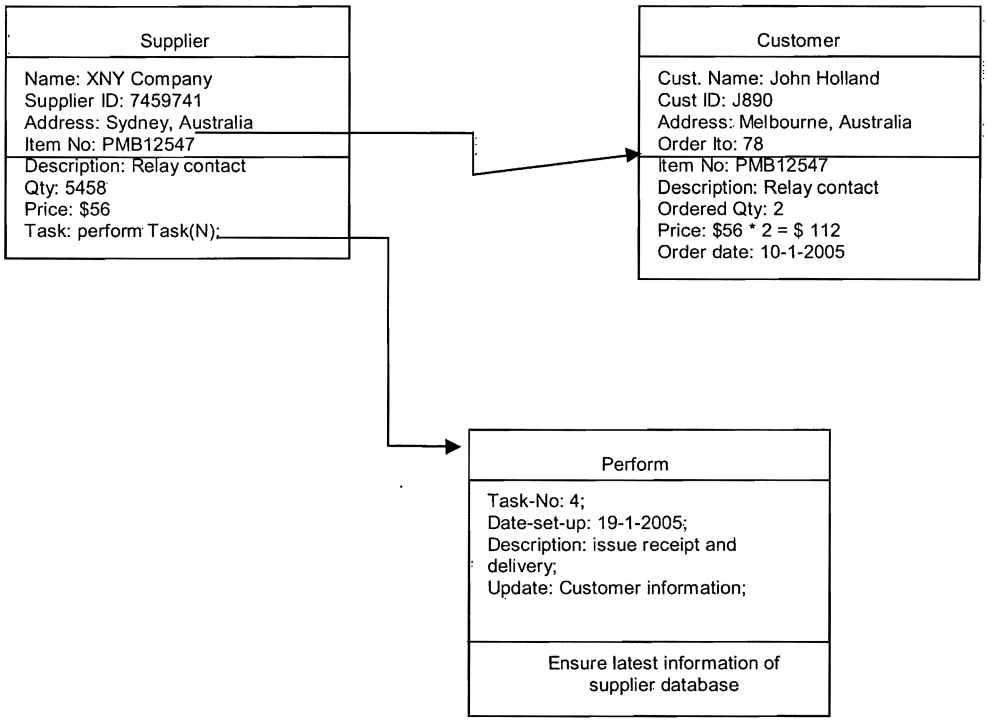


Figure 6-3. Object relationships

To develop knowledge management systems, we need sources of data and information that can span from well-structured databases to dynamically evolving virtual environments and data mining technologies. Data such as supermarket transaction data, bill payments, supplier database and customer database lead to the development of technologies that assist humans in analysing these huge collections of valuable information to facilitate the knowledge management process. Collaborative virtual workspaces are required for this work, as ways of formalising the design requirements toward the workspaces. The ways of structuring the information and activity virtual workspaces depend on a number of factors, including the ontology (what kind of 'place' the underlying environment is), the purpose of the environment, the embedded functionality, the preferred communication and collaboration mode (Meher et al,2000), and the underlying technologies and their integration (Simoff and Maher, 2001). The structure of a virtual workspace usually evolves according to the need of the research. Knowledge can be applied in variations of the workspace structures. Knowledge management requires ways in which people can coordinate

their activities, share their knowledge and create new knowledge. Each activity is defined as a set of roles, which are responsible for taking actions within the activity and viewing or changing documents. Collaboration plays a major role here although it is now realised that a more strategic approach to knowledge management is needed (Hawrysikiewycz, 2001).

This model does not support workspaces and collaboration to share information and activities to set up collaborative workspaces that support different knowledge sharing strategies.

6.2.4 The Collaborative Process Model

The collaborative process model (Sarin et al, 1991) supports the definition, execution, monitoring, and dynamic modification of organisational processes, and is implemented as an object-oriented network service. The model for collaborative work provides for the decomposition of a collaborative process into units of work, the relative scheduling of these units of work, and the flexible assignment and routing of units of work to the people that will perform the tasks.

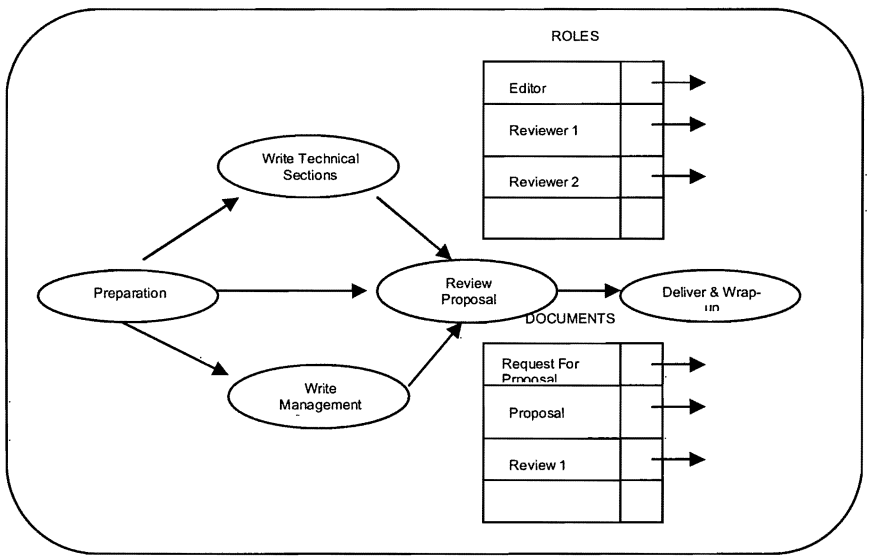


Figure 6-4. Collaborative Process Model (Sarin et al, 1991)

The model consists of a collection of abstract object classes and operations on these classes of objects, which are summarised below.

Jobs: a job is a multi-person collaborative activity with some goals, i.e., a process with a goal. Each job has a ***task*** structure, the work to be performed, and a shared workspace within which users perform the necessary work. Every job has associated with it a set of ***roles***, which are place holders for users who can perform the tasks in the job.

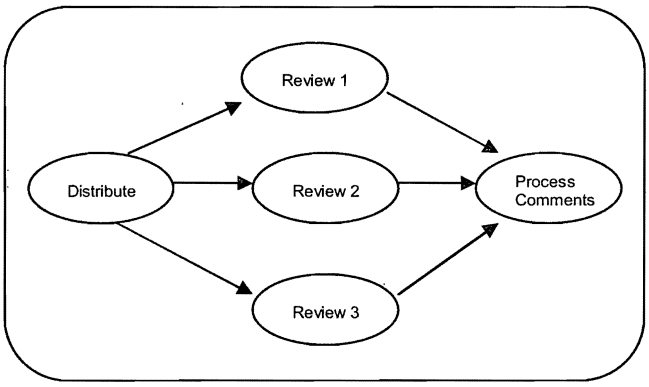


Figure 6-5. Decomposition: Subtasks of "Review Proposal"

Examples: "Editor", "Reviewer 1". A ***document*** in this model is an abstract data object or resources that are manipulated as a unit from a task in a job. To show details of individual tasks, any task in the collaborative process model may be decomposed into sub-tasks, as shown in Figure 6-5.

For instance, when an editor distributes documents to the three assigned reviewers, thay make comments on each document. In the above review task, the "Document to Review" would be the "Request for Proposal" document of the job. The documents associated with a task constitute the context of the task and allow the user working on the task to directly access and manipulate relevant information.

This model only discusses task dependencies of interactions among the tasks performed. Thus, this model is inadequate for more detailed structured workflows and activities. Our research needs a collaborative model that can support collaborative work. We require knowledge about ways to manage collaborative processes to achieve common goals.

In the next section, we discuss a collaborative metamodel to support collaborative processes and workspaces.

6.2.5 Collaborative Business Process Model

A model for collaborative business processes was introduced in (Hawryszkiewycz, 2000) this model provides primarily functional and behavioural perspectives of the process model, and is part of a methodology for the design of collaborative applications.

The collaborative business process model has three major elements:

1. **Roles:** organisational roles with associated rights and responsibilities.
2. **Artefacts:** passive objects, such as documents, used or manipulated in activities.
3. **Activities:** tasks performed by people occupying roles, and affecting artefacts.

Collaborative business process models include notations for representing collaborative processes as well as details of the individual tasks performed by roles. We use a method from soft system methodology (SSM) by (Checkland, 1981). We start with an overall picture of the whole system that may include a number of top-level activities. We then look into more detail at selected activities. The pictures to describe the top-level model and detailed activities are called ***rich pictures***.

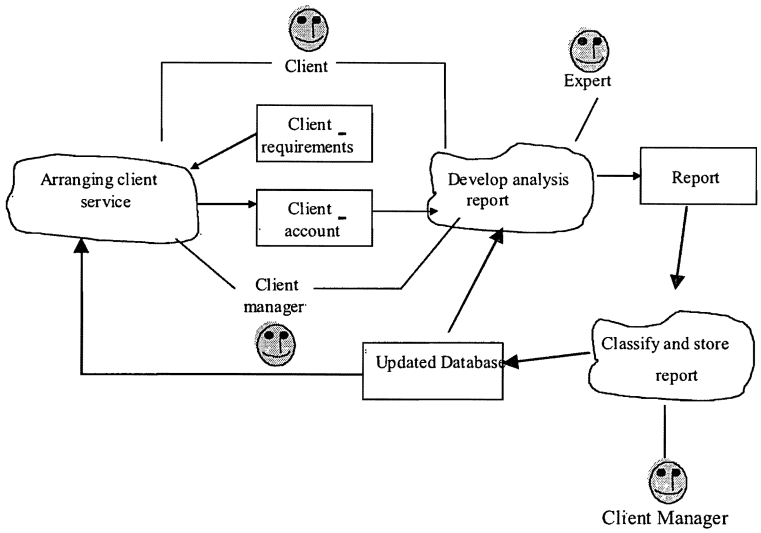


Figure 6-6. A Hawryszkiewycz-style rich picture of the customer service process

The model uses a simplified form of the rich pictures initially defined in soft systems methodologies. The modelling method of Hawryszkiewycz uses a modified form of rich pictures to specify workspaces and to define the components that make up the workspaces. The specification must:

- identify the kinds of workspaces and components needed to build the new system, and
- specify the structure of these components.
- The first step is to identify the needed workspaces.

Hawryszkiewycz introduces standard symbols, syntax and semantics, as shown in Figure 6-6. Here, roles are shown as faced figures, activities as clouds, and artefacts as boxes. The rich picture shows main three activities. One is arranging client service for requirements of clients and client accounts. There is one activity there called "Develop analysis". The outcomes of this activity are reports on the developed analysis. Another activity is to classify and store reports and documents.

The next step in the collaborative business process modelling approach is completed by so-called *transition diagrams,* which express sequencing of activities. Transition diagrams capture the possible transitions between activities in a rich picture Figure 6-7 shows that transition diagrams resemble the task network of Collaborative Process Models.

Each of the activities in a rich picture and its corresponding transition diagram represents one task. When tasks are very large, however, they may need to be decomposed by modelling them as a collection of related sub-tasks.

Figure 6-7 Transition diagram

Hawryszkiewycz (2001) introduces MOO (Multi Object Oriented) diagrams that represent internals of activities as a combination of roles, artefacts, and discussions. At this level, communicative interactions are made explicit. An example of a MOO is shown in Figure 6-8. Here, the polygon represents a discussion, ovals represent roles, and boxes with rounder corners represent artefacts. Arrows represent involvement and use or creation, as above with rich pictures.

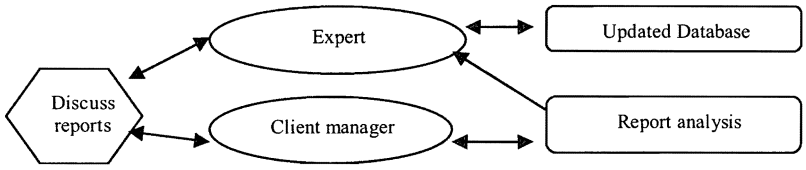


Figure 6-8. MOO diagram for customer services process

Hawryszkiewycz's method with its three process modelling approaches is a way to represent collaborative processes in business processes. We have discussed five different types of model: data flow diagram model, E-R model, object model, the collaborative process model and the collaborative business model. After carefully considering the best model to choose our knowledge management model and integrate the knowledge creation process and the business process, we selected the metamodel concept for collaborative processes (Hawryszkiewycz, 1998). This is discussed in detail in the following sections.

6.3 Knowledge Sharing Processes

The important characteristic of the knowledge creation process is that it cannot be predefined but emerges. Generally it is found that such processes are opportunistic in nature (Dourish, 1999) and result in islands of disconnected work activities, which nevertheless must be coordinated towards some common goal. We consider that activities in any workspace evolve dynamically; especially in a new situation, the activities can be changed quickly. Evolution of activities includes changes in participants, plans, objectives, artefacts, roles, tools and learning. Hawryszkiewycz (2000a) points out that the evolution must be user driven and any collaborative tools should allow the users themselves to initiate such changes and modify their processes. Thus, it should be possible at any time for an activity participant to initiate some new actions and define events and milestones which may need follow-up actions.

Other aspects include the presentation of information in ways conducive to knowledge sharing combined with actions that facilitate interpretation and evaluation (Nonaka, 1994). One way to support the activities found in knowledge-intensive work is to use shared workspaces that can display all the actions in a single workspace and can dynamically evolve. Such integration of actions will allow people to see and

interpret their work in the entire context. Flexibility is achieved through the ability to create a new workspace, invite people into it, initiate new actions, and provide people with the support needed to carry out their work in a collaborative manner. It allows new events to be defined dynamically as work evolves, (Hawryszkiewycz, 2000a).

6.4 Metamodel for Knowledge Intensive Processes

Our experience both in practice and analysis has led to fundamental metamodel concepts and commands that create work environments for KIWA. We have also found that presentation of the concepts to users is critical and have developed alternate presentation methods for the different classes of user roles within an activity. The semantics are that a workspace represents an organisational recognised activity, whose goal is to produce an organisationally recognised artefact. Any number of people may be involved in the activity. The people are assigned roles and can take a variety of actions, both individually or in collaboration with others. Usually the actions are combined into tasks that may be needed to produce intermediate outcomes prior to the production of the activity artefact. Each workspace can include a number of events that can lead to messages being sent to other workspaces, thus supporting emerging workflows.

Workgroups differ from workspaces in two major ways: separation of communities and management of growth. The general effect is that people in a workgroup can only participate in workspaces in that workgroup but not in workspaces of other workgroups. This is needed in situations where there is geographic separation with responsibilities vested in geographic teams, or in situations where one might be managing different client groups that require maintenance of confidentiality between them.

With workgroups, such confidentiality may be maintained to the extent that members of one workgroup are not even aware of who the members of other workgroups are. It is of course possible to have people common to more than one workgroup, who can transfer knowledge between the workgroups or simply move between them.

6.5 Modelling Collaborative Business Processes

The metamodel is described in Figure 6-9 and has evolved through a variety of applications that include business networking (Hawryszkiewycz, 1996) and strategic planning (Hawryszkiewycz, 1997), and is an extension of an earlier description (Hawryszkiewycz, 2002). A further foundation for the conceptual model described here is organization computational theory (Carley and Gasser, 1999) as a basis for managing knowledge about collaborative relationships. Thus, rather than identifying data objects and processes, we identify organizational entities and their agencies. The model shown in Figure 6-9 combines organizational structures such as activities and work-items, work processes including events and workflows, and social structures that enable groups to be formed and participants to be included in such groups. It provides ways to combine work-items into activities, with members of groups assigned responsibilities through roles for those work-items. Here the evolving knowledge management activities can be modelled as work-items and can be grouped in different activities for different users. This model supports social interactions, through group formations, discussions or notifications, as well as more structured workflows by associating events with artefacts.

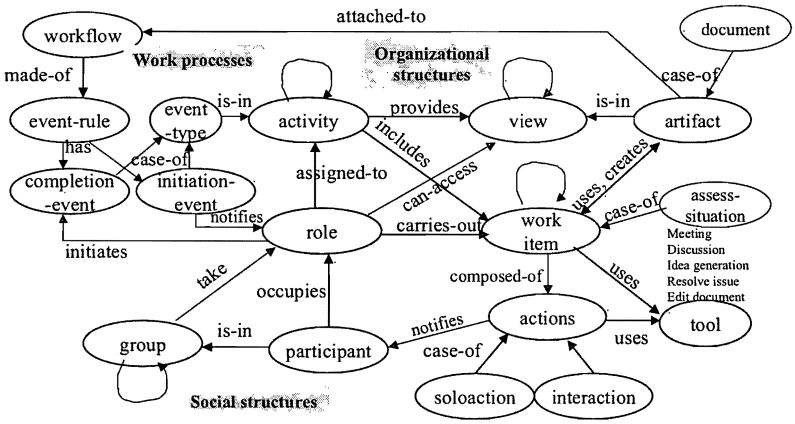


Figure 6-9. Collaborative Metamodel

The main concepts are:

Artefact – a data object such as a document or calendar. It can also be a record of discussions or other personal interactions.

View – a collection of artefacts. These can be documents, calendars, or multi-media records. They can also be other views.

Activity – produces a well-defined artefact as its output (e.g., produce a planning document), and can include many work-items to do so. Provides the views needed to complete the work-items.

Role – defines responsibilities in the system in terms of work-items that the role can carry out and the views that it can access.

Participant – a specific person that is-in a group and can be assigned to a role

Group – a collection of participants that can be assigned to roles.

Work-item – a set of actions and interactions needed to produce intermediate outcomes that eventually produce an activity output (e.g. Review part of a planning document, which may include a number of actions, assess a situation). A work-item is composed of a number of actions and provides tools to carry out the actions. It can also represent a knowledge management activity.

Action – a specific unit of work carried out by a role (e.g. change an artefact, send an artefact). Can notify selected roles when completed. Can be a:

Solo action – carried out by one participant, or an

Interaction – the basic exchanges between people when they collaborate in the activities.

Event type – is in an activity and can either be an 'initiation-event' that notifies a role in the activity to carry out work-item, or is a 'completion-event' initiated by a role following completion of a work-item,

Event-rule – defines the next initiation-event or events to be activated following the completion-event

Workflow – describes a sequence of event rules. Can be attached to an artefact.

The model also includes a variety of commands that can be used up to set up or change systems specified in terms of the model. These include ways to create new groups, activities or work-items and set up the necessary views, workflows and notifications. A typical set of steps followed to create a model are:

1. Define the high-level activities in the system and the work-items in each activity.

2. Define groups or teams and add participants to the groups.
3. Add artefacts needed by the work-items and create views for the work-items to identify the artefacts needed by the work-item.
4. Define roles and assign responsibilities for work-items to roles and then assign participants to the roles.
5. Expand work-items in terms of their actions and identify views for these to 'use or create' artefacts.
6. Identify any predefined events and consequent rules and specify the 'initiation-events; to be activated following a 'completion-event'. Workflows are 'made of' sequences of event rules.

6.5.1 Notation used in describing systems using the collaborative metamodel

We now describe how to use these semantics to model collaborative applications and implement the models. Integration into business processes requires the ability to show how EKP knowledge activities are placed into activities and then to allocate the action to a person responsible for it.

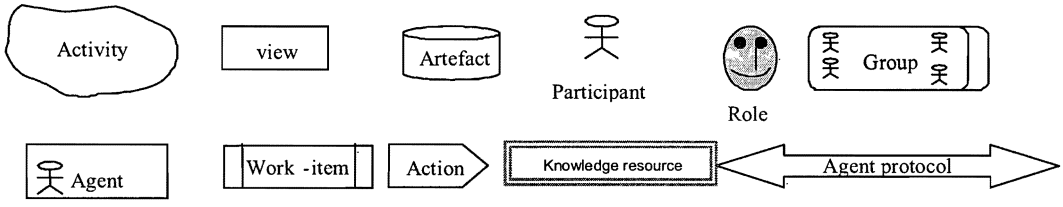


Figure 6-10. Notation

Figure 6-10 shows the notation used to describe models in terms of the proposed semantics. The notation includes symbols which correspond to those in other methodologies such as Prometheus, as the goal is to extend to agent systems. Others are specific to the model. Thus, we use a loose cloud notation for activities as we see activities not being fixed but evolving over time through creation of new work-items or roles as needed.

The loose cloud shape shows that new activities can be easily formed by grouping existing work-items. A double-line rectangular box represents a knowledge resource. The event structure is also different to make a distinction between completion and

initiation events and also to distinguish from agent events that are part of agent architectures.

6.6 Supply Chain Management as a Business Process

Figure 6-11 illustrates a model of supply chain management using the concepts illustrated in Figure 6-9. It is based on descriptions found in (Simchi-Levi, 2000). The objective of supply chain management is to minimize costs by reducing inventories while ensuring on-time delivery of customer orders. Every activity in supply chain management can impact on cost and plays a role in making the product conform to customer requirements while ensuring a smooth path from suppliers through warehouses and distribution centres to retailers (Maung, 2004a).

We describe purchasing, order processing and distributions activities in Figure 6-11, using loose cloud notations for these activities. Shaded boxes represent work-items in each activity. We will use these notations in the following sections and further chapters.

In supply chain management, the ordering department orders many different types of items from the different suppliers. When order requests arrive in the order department, they find out what items must be ordered. As soon as a need has been identified and precisely described, the order department begins an investigation of the market demands and seasonal demands to identify sources of supply. The Order Manager and team participants are responsible for selecting sources, managing costs, and carefully selecting suppliers. They manage quality of products and the costs of transport, holding, and time required to bring products to market.

Order managers, buyers, and purchasing agents search to obtain the highest quality product at the lowest possible purchase cost. They determine which products or services are best, choose the suppliers of the product or service, negotiate the lowest offering prices and ensure that the correct amount of the product or service is received at the appropriate time. In order to accomplish their assignments and tasks successfully they have to do market research, survey customers, identify suppliers, and assess market demand for needed products and materials. To assist them in their search, they review catalogues, brochures, price lists, magazines, journals, company publications, company annual reports and directories. When all the necessary

information is gathered, they place the orders and contracts to suppliers who meet the requirements of the company. Order clerks often work closely with other employees within their own company as they consider when to order product, study inventory level of stock, satisfaction and quality of product or service of suppliers.

Buyers and sellers communicate information through price; as well, an exchange of product takes place when they can agree upon a price. They determine price by market demand and quantity supplied. An increase in the price of a good may be associated with a fall in the quantity demanded and a decrease in the quantity supplied. The equilibrium price is established at the point where the quantities supplied and demanded is equal. At the equilibrium price the market is "cleared". When either demand or supply shifts, the equilibrium price will change.

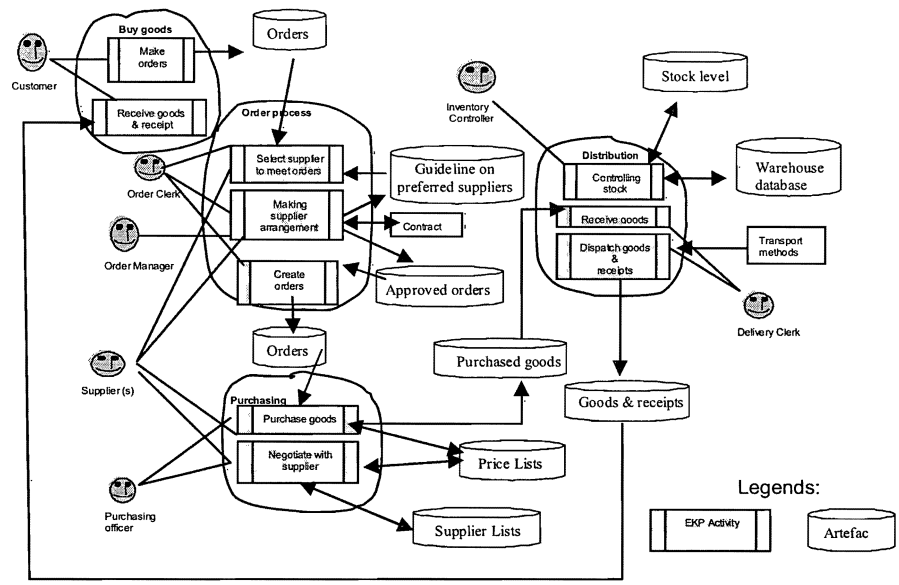


Figure 6-11. Supply Chain Management – top-level diagram

The activities in Figure 6-11 include:

- ***Buy goods***, where the customer makes an order request.
- ***Order processing***, where the ***order clerk*** uses order requests to make arrangements with ***suppliers***. The order manager provides procedure and a set of contracts and guidelines on preferred suppliers to the ***order clerks,*** who issue orders in response to customer requests.
- ***Purchasing***, where the ***purchasing officer*** negotiates with the suppliers to discuss goods and prices.

- ***Distribution***, where warehouse facilities (such as storage cost, storage time, location, stock in store and distance) are provided the ***inventory controller*** to control stock levels and warehouse locations, and the ***delivery clerk*** uses facilities to receive goods and dispatches goods with receipts to ***customer.***

6.7 Integrating EKP Activities

In this section, we describe some examples to illustrate integrating EKP activities into order process in supply chain management and on-line teaching process. Firstly, we explain order process and then on-line teaching process.

The next step is to add the EKP work-items to the activities shown in Figure 6-11. The way this is done depends on the chosen knowledge management strategy. Figure 6-12 illustrates the alternative in which the EKP activities are distributed through the different business activities whereas consolidation is centralized. Each EKP activity becomes a work-item. Figure 6-12 shows the EKP activities for the order activity as shaded work-items The model also defines the specific roles responsible for the work-items; in this case the order manager would carry out all the tasks. In Figure 6-12, we associate knowledge resources (double-line rectangular boxes) with the actual data object, then implement a distributed knowledge policy. An alternative would be to centralize the EKP activities (Hawryszkiewycz and Maung, 2004). This would require a separate high-level activity of knowledge management with information sent to it from other activities for knowledge processing.

Figure 6-12 describes a set of activities that are often found in the "Order process" activity in supply chain management. There is a top-level rich picture that describes the entire process, shown in Figure 6-11. Here, we only discuss the order process activity.

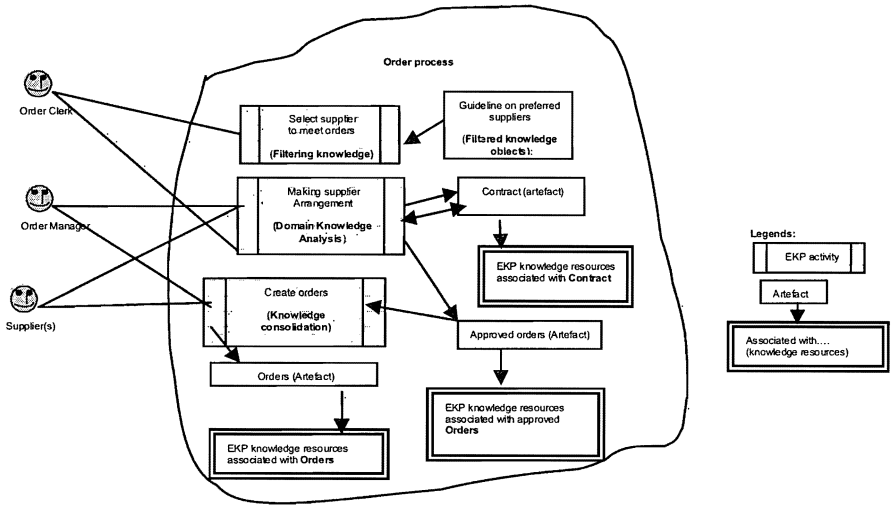


Figure 6-12. Integrating EKP activities into the business process
(Example: Order process in supply chain management)

Research shows how the EKP activities in ***Order activity*** allocate the responsible person for the actions in Figure 6-12. These EKP activities are associated with knowledge resources. For example, when the ***Order Manager*** makes an arrangement (Shaded work-item *Domain Knowledge Analysis*) with ***Suppliers***, she produces a set of contracts and also adds to guidelines on preferred suppliers. These guidelines are the filtered knowledge objects.

Each purchasing activity and distribution activity has its own agent to coordinate with other EKP activities and other work-items (Hawryszkiewycz and Maung, 2003c).

The previous section has discussed integration of EKP activities into business processes using supply chain management as an example. In the next section, we discuss the integration of EKP model into different environments of business processes.

6.8 Applications of EKP Model

The previous section has discussed integration of EKP model into business processes. This section discusses applications of the EKP model in different business processes.

Example: Online Learning

Today, internet technology is another tool for teaching and learning online. It is rapidly growing in popularity world-wide. Students can save the time to go to university by taking courses over the Web because they find the medium so flexible. Teachers find that online courses allow more time for discussion, and allow collaboration of learners as well as trainers. Online teaching and learning is another example of constructivist types of learning. Online courses may be appropriate for both traditional and non-traditional students; they can be used in undergraduate education, continuing education, and in advanced degree programs. Online teaching and learning can be done with high quality if new approaches are used that allow for the limitations of the technology, and if professors can maintain the interest of their students. They can also save time and labor. Another advantage is that teaching in the classroom requires more time and money. With online learning, there are no worries about locations and numbers of student for classroom time table.

Teachers use blended learning to encourage students to use the internet for research, or retrieve resources from a CD, or use online materials. Teachers should empathise with students and know their frustrations. Research links the knowledge creation process to creativity, innovation and implementation in online teaching approaches. Knowledge management activities are seen by many as detracting from the main online teaching activities and as such are often ignored or left until some free time becomes available. Alternatively, knowledge management activities are carried out independently of online teaching activities.

Integration into online teaching processes requires ways to show how EKP knowledge activities are placed into activities and then how the action is allocated to the person responsible for it. Figure 6-10 also shows the notation used to describe models in terms of the proposed semantics. The notation includes symbols corresponding to those in other methodologies such as Prometheus, as the goal is to extend to agent systems. Other symbols are specific to the model.

Thus, we use a loose cloud notation for activities as we see as not being fixed but evolving over time through creation of new work-items or roles as needed. The loose cloud shape portrays the fact that new activities can be easily formed by regrouping existing work-items.

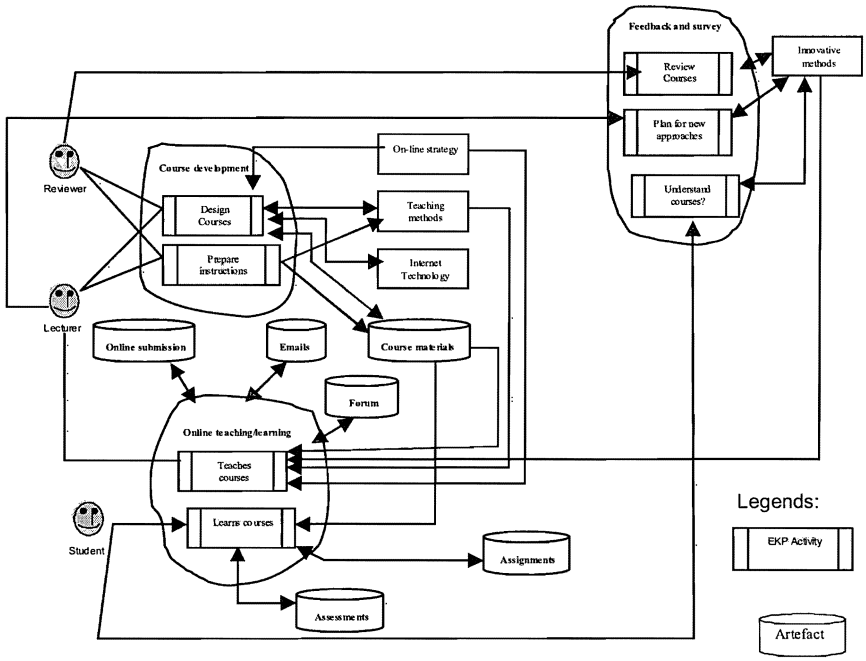


Figure 6-13. Online Teaching – top-level diagram

The event structure is also different to make a distinction between completion and initiation events and also to distinguish from agent events that are part of agent architectures.

The activities in Figure 6-13 include:

- **Course development**, in which ***Reviewer*** and ***Lecturer*** design the course and prepare instructions. They use internet technology, apply teaching methods, online strategy and produce course materials.
- **Online teaching and learning**, in which ***Lecturer*** teaches the online course and ***student*** studies the course. They use email, discussion forum for discuss with other group of students and online submission of assignments and assessments.
- **Feedback and survey**, in which ***Reviewer*** and ***Lecturer*** review courses, plan new teaching approaches and innovate teaching methods. ***Students*** report and discuss their problem and difficulties from online programs.

Integrating EKP Activities into the Online Teaching Process

The next step is to add the EKP work-items to the activities shown in Figure 6-14. The way this is done depends on the chosen knowledge management strategy. Each EKP activity becomes a work-item. Figure 6-14 shows the **EKP activities** as shaded

work-items but only for the ***course development*** activity. The model also defines specific roles responsible for the work-items. In this case the online ***Lecturer*** should carry out all the tasks.

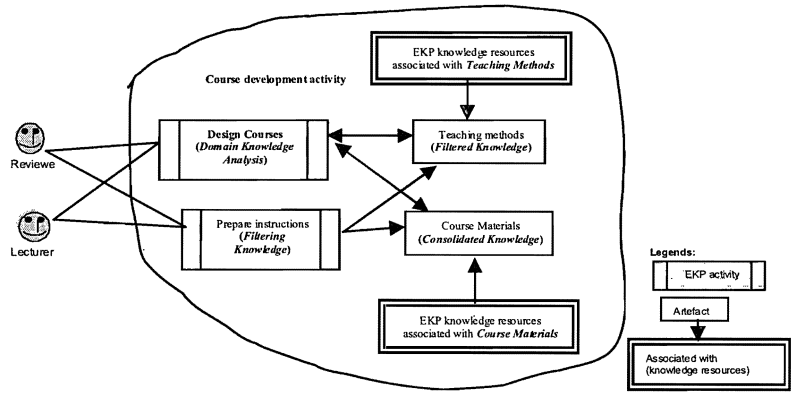


Figure 6-14. Integrating EKP activities (Example: course development activity)

In Figure 6-14, we associate knowledge resources with the actual data object, then implement a distributed knowledge policy. An alternative would be to centralise the EKP activities: there would then need to be a separate high-level activity of knowledge management with information sent to it from other activities for knowledge processing.

The knowledge management process of **"course development activity"** involves such activities as course description, course structure (component of the course), class room activities, assignments, student assessments, course assessment and examinations. Figure 6-14 illustrates two work-items for course development activities: design course and prepare instructions. We discuss knowledge management of course development activity that is integrated with EKP activities.

When ***Lecturer*** and ***Reviewer*** design a course, the shaded work-item *Domain Knowledge Analysis* consists of a brief description or overview of the course. They should consider why the course is needed and what it will provide for students. They possess domain knowledge about educational problems and opportunities addressed by the course, both in terms of student concerns and the demands of the academic or professional community. The reason for offering the course and its objectives should

be clear in the course proposal. Learning objectives for students must be organised for the course, including a set of more specific objectives for student learning outcomes.

Instructions should be prepared (Shaded work-item: *Filtering Knowledge*) that can be expressed as components of the course (course structure) and explain the major critical issues, questions and topics of instruction which function as the organising components of the course, ***Lecturer*** and ***Reviewer*** need to consider the descriptions of the major components of the course and show how they relate to one another and how they are integrated to form a coherent course. They may also decide how the components of the course are linked to core requisites. Other activities in preparing instruction work-items are:

(a) **Class room activities:** descriptions of activities of the course should be provided as student activities involving learning outcomes. Each learning objective has activities that should be specified sequences in the course.
(b) **Assignment and Exams:** group and individual assignments and examinations should be involved.
(c) **Student Assessment:** monitoring the performance and progress of student.
(d) **Course Assessment:** Evaluating the effectiveness of the course and reflection on learning outcomes from the students. How student learning outcomes are assessed by assignments and examinations.
(e) **Student Survey:** Questionnaire for course and teaching staff survey can support progress and development of course.

The kind of interaction illustrated in Figure 6-13 requires participants to be aware of EKP activities they need to carry out. Participants are often busy and can sometimes overlook and not carry out the EKP activities. Furthermore, experts with the needed tacit knowledge in the EKP activities are often not known or are not easily available. We can use software agents to facilitate this process. Software agents are autonomous pieces of software that sense their environment and take actions based on the environment conditions. Each EKP activity has its own agent, which will have the ability to find the right experts and to coordinate with other EKP activities and the other work-items. The capabilities include: notify a participant to start a knowledge management activity; provide tools to accomplish the activity; find knowledge

resources needed in the EKP activity; and setup a workspace suitable for the EKP activity.

6.9 Summary

This chapter has discussed the methodology for the integration of EKP models into business processes. It started by showing the knowledge intensive processes in organisations, explaining how organisations use information resources in effective ways to identify new products and services on the internet as electronic communities. Then we explained metamodel concepts to describe business processes and knowledge sharing processes.

Next, we described modelling concepts for collaborative business processes that combine organisational structures such as activities and work-items, work processes including events and workflows, and social structures. Then, we discussed how to integrate EKP activities into business processes using supply chain management as an example. We also discussed applications of the EKP model in different business processes using the online learning process as an example. We thus have discussed two examples, supply chain management and online learning, to show the integration of EKP activities into business processes.

The next chapter introduces an agent methodology that supports and facilitates the knowledge management process; each activity of EKP has its own agent to facilitate the business processes.

Chapter 7

Facilitate the Process

The previous chapter described a method for integrating KM into business processes. The present chapter is concerned with agents that support and facilitate the knowledge management process. The idea of facilitating processes by using agents is interesting, since agents have to be customised for each EKP activity. An agent, for example, maintains interaction with its environment (performing actions in response; reactiveness), must be able to take the initiative (proactiveness), must be able to perform social actions (communication and cooperation), and must be able to generate goals independently and act rationally to achieve them (planning and plan execution; autonomy).

Since agents act in an environment that contains other agents and various activities and services, an agent interaction architecture is needed to standardise communication between agents and access to common services. An agent's interaction architecture should provide support for agent-to-agent communication and communication across each activity in the knowledge management process.

Thus, we have to define a generic agent structure that includes agent perception, agent knowledge about how to obtain the best sources of information needed in an activity and knowledge about the best ways to carry out the activity. We also identify agents in each EKP activity to support and facilitate the process; this is our challenge in this thesis. The agent will contain the necessary knowledge to identify points in the process where knowledge should be processed and provide the tools to carry out the necessary knowledge management functions.

This chapter describes the generic agent structure, agent perception, EKP multiagent systems, and individual agents of EKP with their goals, plans and action and communication of each agent. In the following section, this chapter provides a definition of the generic agent, and describes how to identify EKP agents and how to facilitate the process in more detail.

7.1 An Agent

This section describes different ways of defining agents. An agent, according to Webster's New World dictionary, is "a person or thing that performs an action to bring about a certain result, or that is able to do so ... one who acts, or is empowered to act, for another". An agent can be a person, a machine, a piece of software, or a variety of other things. The basic dictionary definition of agent is *one who acts.* An agent (sometimes called an "adaptive agent") is generally regarded as an autonomous entity that can interact with its environment. In other words, it must be able to perceive its environment through sensors and act upon its environment with effectors. There is no universally accepted definition of the term agent, and indeed there is much ongoing debate and controversy on this subject (Wooldridge, 2001).

Nevertheless, some sort of definition is important, otherwise, there is a danger that the term will lose all meaning. The definition presented here is adapted from Wooldridge and Jennings (1995). An *agent* is a computer system that is situated in some environment, and that is capable of *autonomous action* in this environment in order to meet its design objectives An agent's decision function selects *actions* as responses to *sequences* of environment states (Wooldridge, 2001). Agents are able to act without the intervention of humans or other systems: they have control both over their own internal state, and over their behaviour.

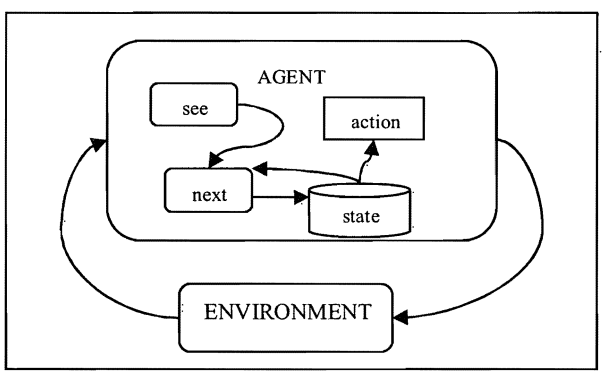


Figure 7-1. Agents that maintain state.

The agent takes sensory input from the environment, and produces as output actions that affect it. The interaction is usually ongoing and non-terminating. In a top-level view, an agent's decision function responds to sequences of environment states or

percepts with actions, as shown in Figure 7-1. In this diagram we can see the action output generated by the agent in order to affect its environment. In most domains of reasonable complexity, an agent will not have complete control over the environment. It will have at best partial control, in that it can influence it.

The key problem facing an agent is that of deciding which of its action it should perform in order to best satisfy its design objectives. The complexity of the decision-making process can be affected by a number of different environmental properties. Russell and Norvig (1995) suggest the following classification of environment properties:

- Accessible vs inaccessible

An accessible environment is one in which the agent can obtain complete, accurate, up-to-date information about the environment's state. Most moderately complex environments (including, for example, the everyday physical world and the internet) are inaccessible. The more accessible an environment is, the simpler it is to build agents to operate in it.

- Deterministic vs nondeterministic

As we have already mentioned, a deterministic environment is one in which any action has a single guaranteed effect – there is no uncertainty about the state that will result from performing an action. The physical world can to all intents and purposes be regarded as nondeterministic. Nondeterministic environments present greater problems for the agent designer.

- Episodic vs non-episodic

In an episodic environment, the performance of an agent is dependent on a number of discrete episodes, with no link between the actions of an agent in different scenarios. An example of an episodic environment would be a mail sorting system (Russell and Subramanian, 1995). Episodic environments are simpler from the agent developer's perspective because the agent can decide what action to perform based only on the current episode – it need not reason about the interaction between this and future episodes.

- Static vs dynamic

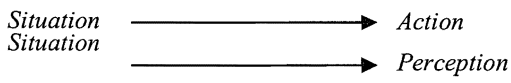
A static environment is one that can be assumed to remain unchanged except by the performance of actions by the agent. A dynamic environment is one that has other processes operating on it, and which hence changes in ways beyond the agent's control. The physical world is a highly dynamic environment.

- Discrete vs continuous

An environment is discrete if there is a fixed, finite number of actions and precepts in it. Russell and Norvig give a chess game as an example of a discrete environment, and taxi driving as an example of a continuous one.

Agents with States

An agent's decision function responds to sequences of environment states or percepts to perform actions (Wooldridge, 2001).



An agent has at lease three distinctions:

- Agents embody stronger notions of autonomy than objects, and in particular, they decide for themselves whether or not to perform an action on request from another agent.
- Agents are capable of flexible (reactive, proactive, social) behaviour, and the standard object model has nothing to say about such types of behaviour.
- A *multiagent system* is inherently multi-threaded, in that each agent is assumed to have at least one thread of control (Wooldridge et al., 1995).

Newman and Conrad (1999) consider that knowledge artefacts do not perform actions and make decisions. Actions and decisions are taken undertaken by people, technology, organisations, experts, software, or other physical or virtual entities (Newman and Conrad, 1999).

Ferber (2000) describes agents as follows:

(a) capable of acting in an environment,

(b) can communicate directly with other agents,

(c) are driven by a set of tendencies (in the form of individual objects or of a satisfaction/survival function which they try to optimise),
(d) process with their own resources,
(e) capable of perceiving their environment,
(f) have only a partial representation of this environment (or perhaps none at all),
(g) possess skills and can offer services,
(h) may be able to reproduce themselves,
(i) their behaviour tends towards satisfying their objectives, taking account of the resources and skills available and depending on its perception, its representations and the communications it receives.

In the next section, we describe how to define our generic agent structure and its perception and in the following section we will discuss each agent for EKP model and how to facilitate the process in detail.

7.1.1 Intelligent Agents

An intelligent agent is one that is capable of flexible, autonomous action in order to meet its design objectives (Wooldridge and Jennings, 1995). We consider developing EKP agents that are based on the following properties.

Reactivity: Intelligent agents are able to perceive their environment, and respond in a timely fashion to changes that occur in it to satisfy their design objectives.

Proactiveness: Intelligent agents are able to exhibit goal-directed behaviour by taking the initiative in order to satisfy their design objectives.

Social ability: Intelligent agents are capable of interacting with other agents (and possibly humans) in order to satisfy their design objectives.

Firstly, we consider *proactiveness*, goal directed behaviour. It is not hard to build a system that exhibits goal directed behaviour – we write research reports that describe

research objectives, plan, literature review, background theories and concepts, methodology, development and implementation in computing research.

Secondly, most domains are too complex for an agent to observe completely. Also, they may be populated with more than one agent that can change the environment, or there may be uncertainty in the environment. In such dynamic environments, an agent must be *reactive*. That is, the agent must respond to events that happen in its situation where these events affect the agent's goal or the agent's ability to achieve its goals.

Thirdly is *social ability,* we may understand other people's goals and plans, and we may perform actions and negotiate and cooperate to achieve goals. In the next section, we describe the generic agent structure and its perception and EKP multiagent system.

7.2 Generic Agent Structure

Agents are often designed to perform their own specific tasks, for example their activities produce an artefact. We need to identify an agent's task and the agent needs to be able to perform the task. Agent abilities include reactiveness, proactiveness and social abilities. Proactiveness is related to an agent's ability to reason about its own processes, goals, and plans and to control these processes. Reactiveness and social ability are related to the ability to be able to communicate with other agents and to interact with the external world. The structure of the generic agent needs to identify specific task components to perform its activity.

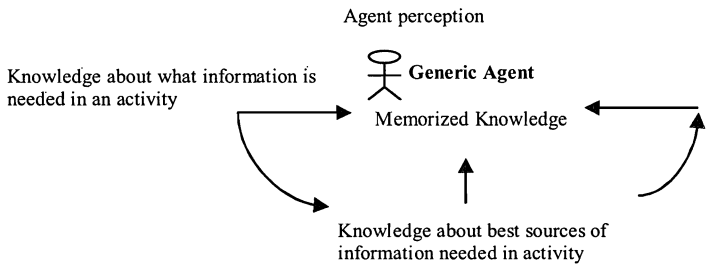


Figure 7-2. Generic agent structure

The structure of the generic agent includes agent perception, agent knowledge about what information is needed in its activity, knowledge about the best sources of

information needed for an activity and knowledge about the best ways to carry out an activity.

7.2.1 Agent Perception

An agent is able to perceive the environment, act in this environment and communicate with other agents. The agent has an associated knowledge base and set of beliefs that represent what the agent *knows* and the set of goals to be achieved. Figure 7-3 illustrates how a single generic agent in a multiagent system connects to the collaborative environment (Metamodel of collaborative environment, Figure 6-9), and there is a collaborative database that contains descriptions of the current collaborative activities. These are linked to the collaborative environment through *events* (from the collaborative environment to an agent) and *actions* (from an agent to the collaborative environment). The agent stores collaborative actions and events in its internal knowledge base.

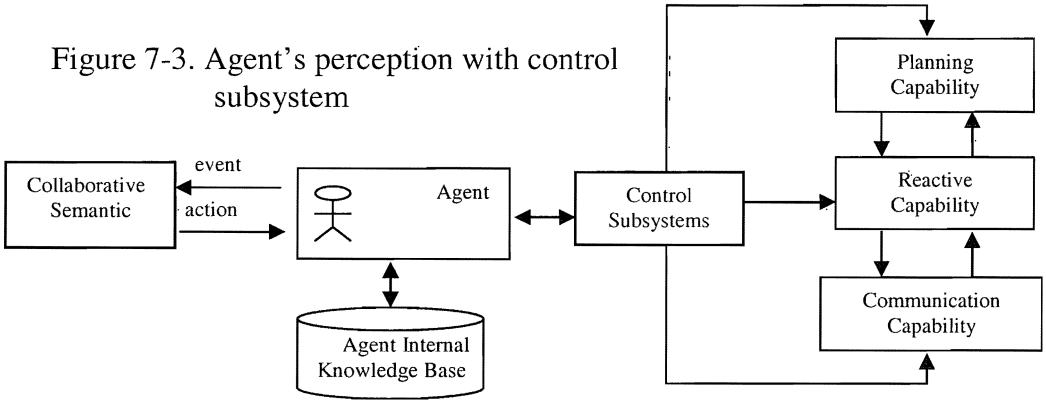
An agent has a control subsystem to control its *planning capability*, *reactive capability* and *communication capability*. The agent looks for relevant plans and then, for each relevant plan, the agent looks at its appropriateness to the situation the agent finds itself in. The agent then selects and starts executing the most appropriate plan found or the agent finds what goal to achieve or alternatively how to react or change to another goal. The agent chooses the people who can support the plan with their experience, skill and knowledge in specified area of interest.

Goals (Activities): the goals that the agent can achieve (What to do?)

Plans: the plans that the agent has

Actions: the actions that the agent has (*Who, Where, What, Why, When and How = 5Ws & H*)

Figure 7-3. Agent's perception with control subsystem



(a) Knowledge about what information is needed in an activity

Knowledge about what information is needed in an activity is the first important step in gathering information and data.

(b) Knowledge about the **best sources for information needed in an activity**

Knowledge about best sources comes from domain-specific knowledge that comes from the study of the field itself, The source is usually an expert in the field. Some domain knowledge that may be useful to classifiers is available in the form of existing knowledge sources. The knowledge from these sources can be used to identify best sources for knowledge accumulation, domain knowledge analysis and knowledge filtering activities in EKP activities.

(c) Knowledge about best ways to carry out activity

An agent seeks to understand the ways in which knowledge is accessed, created and used in the agent's activity.

In the following sections, we describe intelligent agents, interaction of EKP agents and how EKP agents support and facilitate the process in more detail.

7.2.2 EKP Multiagent System

Our research studies the interaction of EKP agents in charge of producing knowledge object structures in the knowledge creation process to provide precisely the information needed, precisely when it is needed. Each kind of agent brings unique and essential capabilities to knowledge objects to facilitate the process. EKP agents focus their capabilities within a specialised domain of interest.

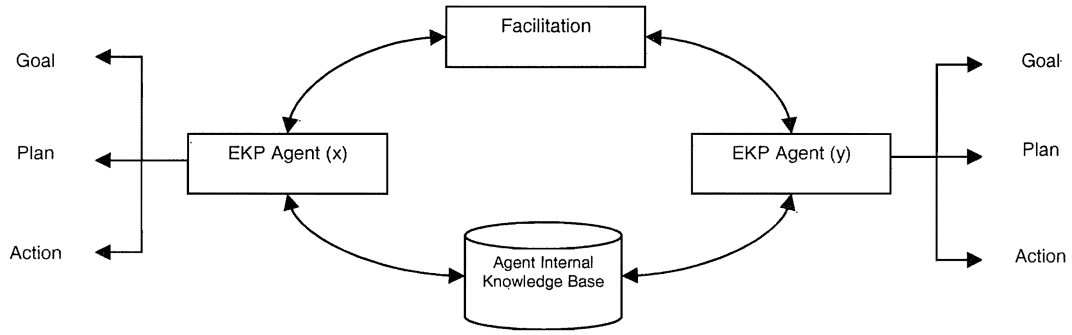


Figure 7-4 EKP multiagent system to facilitate the process

It is clear to us where the needed agent roles and interactions could be identified. In our multiagent system, an agent exists and performs its activity to facilitate the process in which other EKP agents cooperate. Therefore, coordination among agents is essential for achieving their goals and performing activities, for both self-interested and collectively motivated agents. This chapter presents a multiagent system in which all EKP agents are aiming to achieve their goals through their internal knowledge bases with other agents in the system. In this way, agents will be able to evolve their goals, plans and activities to facilitate the process. Our approach focuses on each EKP agent's capabilities, performance and their interaction.

First, we describe the interactions of EKP agents and later in the following sections we will discuss the capabilities of each EKP agent.

7.3 Knowledge Accumulation Agent

A knowledge accumulation agent assists us to capture knowledge, information and data during the gathering and collecting stages. It has capabilities within a specialised area of interest. Knowledge accumulation is the initial step in the EKP model. From a knowledge management point of view it is important to find ways to use, reuse, capture and store knowledge as efficiently as possible.

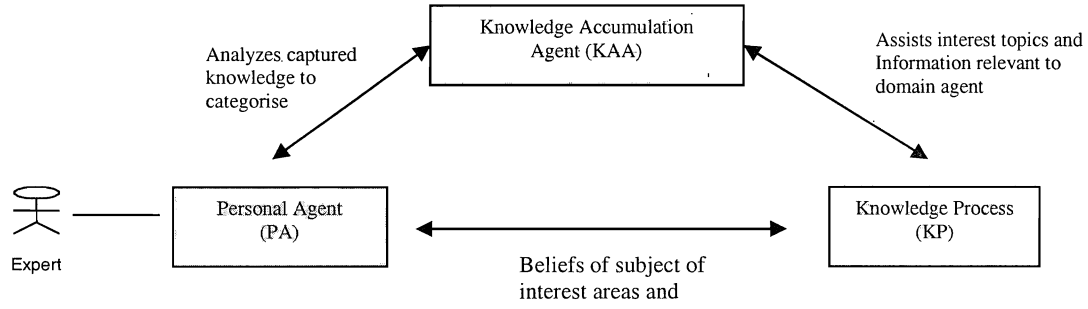


Figure 7-5 Process of knowledge accumulation agent (KAA)

A personal agent (an expert) needs a large amount of reliable knowledge and information when gathering the knowledge, information and data required for a knowledge process (KP) agent. Such a process starts by gathering the personal agent's needs and requirements, usually implying the following steps: identifying appropriate users, interviewing them to discover their work practices and workspaces, learning work documents, identifying what users need are and where support can be provided.

users, interviewing them to discover their work practices and workspaces, learning work documents, identifying what users need are and where support can be provided.

Figure 7-5 shows an expert personal agent (PA) searching for a person who has knowledge about relevant information and/or finding knowledge resources, information and data. The knowledge accumulation agent (KAA) assists us to find the required sources in formal or informal ways.

Our research focuses on how to capture and structure information to enable the knowledge creation process. The KAA needs to obtain sources of information relevant to the domain of expertise. The KAA supports a single application domain and provides access to the available information sources within that domain.

The KAA answers the following questions:

- What are the important information and data?
- What resources will be the most appropriate and efficient?
- How can we bootstrap creativity and innovation?
- What are the best ways of gathering information and data?
- What technologies can assist?
- How can we obtain and use knowledge, and which resources should we use?

With the growing number of information sources available, the problem of how to combine distributed, heterogeneous information is becoming increasingly critical. The available sources include traditional databases, files, knowledge bases, and sources from different people and organisations.

The solution to this problem is to provide access to a large number of information sources and organise them by a knowledge accumulation agent that assists expertise on a specific topic through drawing on relevant information from information sources.

7.3.1 Sources for knowledge accumulation

The following are possible sources for a knowledge accumulation agent to approach:

Experts: Subject matter experts are the primary source of knowledge.

Clients: Clients see things from different viewpoints and can consider and advise on many major issues.

Multiple Experts: Multiple experts are useful for finding different sorts of expertise and for confirmation of good solutions.

Literature: The literature is useful for understanding for an overview of the domain knowledge and to clarify terms and terminology.

Other sources of information: There are various sources of information such as internet, newspapers, journal, magazine, organisation website, brochures and documents, competitors, people from inside and/or outside organisation.

7.3.2 Best ways to accumulate knowledge

Knowledge accumulation is the most important and difficult phase for the knowledge accumulation agent. All relevant information must be collected and the agent can use various methods and approaches as follows:

Interview method: an agent interviews experts or clients. This involves asking direct or indirect questions about the problem domain and recording all the answers to analyse.

Previous method: an agent uses case studies, from which knowledge and information are gathered by observation of the expert in the process of finding a solution.

Questionnaires: are tools to gathering information and knowledge.

Internet and website: an agent collects, organises, and presents information from the internet and appropriate websites.

Other sources: documents, journals, magazines and newspapers can provide information and knowledge.

Internal people: Internal people in the organisation are sources of information and knowledge.

Approach: The agent approaches a person or people to obtain information.

Planning Capability

The planning capability identifies, manages and collects all information assets, including database, internet, media, documents, polices and procedures and experience embodied in individuals to organise actions and specify the activity to achieve a goal through various methods and approaches of accumulating knowledge.

Reactive Capability

The reactive capability compares its goal specification with resources to determine the agent's commitment in the planning capability. It refines planning with a sound notion of action to invoke a partial plan towards goal satisfaction while minimising resource consumption and detects any significant mismatch between the initially expected and the currently expected utility brought about by a plan.

Communication Capability

The communication capability manages the following processes associated with EKP activities: the ability to receive a message and interpret the sender's meaning correctly, the ability to assess the reliability of messages, the ability to create a message which matches the plan.

In the following sections, supply chain management will be an example for EKP activities in knowledge accumulation.

Goal: Good Knowledge Accumulation

Sub-goal (1) Find Source of information about interest subject area

When an agent has a goal to find a source of information for interest subject area, she needs to make a plan. First, the agent must identify the subject area and interests. The agent can then identify sources and collect information and select people who can help find out the required information.

Sub-plan How to find source of information by interest area:

(a) Identify what information is needed by subject area.

(b) Collect catalogues, brochures, journals, magazines by subject.

(c) Select people.

(d) Look for required information on the departmental internet site.

Rules

- If a source of information is useful for interest subject area, then send it as a file or document to the person who is interested.
- If person *x* cannot find the source of information, then find person *y* who knows the subject area, or search other sources.
- If information on previous client needs is missing, then distribute a questionnaire.
- If questionnaires have been sent in the past and no reply received, then request a response.
- Check-if-disagreement: find new ways of searching for information
- Arrange discussion: meeting with people and distribute agenda.

Actions

- Communicate with responsible person in an organisation.
- Create and update documents, files and computer databases.
- Negotiate with people.
- Develop ideas for important conversations.
- Observe how people perform.

Example

The purchasing department buys many different types of items from different suppliers. When purchase requests arrive in the purchasing department, department personnel find out what items should be ordered. As soon as a need has been identified and precisely described, the purchasing department begins an investigation of the market demands and seasonal demands to identify sources of supply. The Purchasing Manager and team are responsible for selecting sources, managing costs, and carefully selecting suppliers. They manage quality of products, cost of transport, holding, time required to bring products to market.

Sub-goal **(2) Determine usefulness and value of information in subject area**

Information is valuable only to an agent that needs it and can use it. The agent can determine the value of information in terms of completeness, accuracy, timeliness, consistency, relevance, appropriateness, validity and uniqueness.

Sub-plan **How to determine whether information is useful and valuable**

(1) Define types of information to search.

(2) Select useful sources of information and data.

(3) Select subject matter experts or an organisation in the interest area.

(4) Search best people given earlier experience.

Rules

- If the received information meets the requirements, then carry out the necessary action, otherwise search for more information and data.
- If there is slow progress for reporting, then find new good role structures to progress the activity.
- Information must be complete, otherwise bad or wrong decisions can be made.
- If the information is accurate, the best judgement the agent can make depends on each piece of information.
- Information must be up-to-date.
- Information must be validated, consistent, appropriate and unique.
- Check-if-disagreement: find alternate method for decision.
- Arrange discussion: meeting with participants and distribute agenda.

Actions

- Focus on interest subject area and identify objectives.
- Analyse and understand information that is necessary to act.
- Discuss and interview with expertise in subject area.
- Specify the reason for acceptance of quality and value of information.
- Find a new participant for the role.
- Advise on alternative approaches for making decision before going ahead.
- Organise information with care.

Example

The purchasing department focuses on objectives for price, cost, performance, market availability, quality, and reliability of product. Purchasing and supply management team members identify and qualify potential suppliers to buy good quality of product. Buyers interview present and potential suppliers, and visit new suppliers. Through

such activities, the buyers will become aware of new products and their quality, and new technologies which may be of interest. This information may help the purchasing managers responsible for identifying and buying new products.

Sub-goal **(3) Collection right information**

Obtaining the right information from the right source is very important for the agent. The question is: How to obtain the right information at the right time?

Sub-plan How to get the required information

Rule

- Inadequate information must avoid.

Actions

- Find out what information is needed, who will provide the right information and how it will be obtained.
- Ask open-ended questions and develop the facts with who, when, where, why, what and how (5Ws and H).
- Analyse the results and respond appropriately.
- Determine what really happened and who to believe.
- Investigate reports with description of documents reviewed, finding of fact, evidence, conclusion and summary.

Example

Purchasing managers, buyers, and purchasing agents search to obtain the highest quality product at the lowest possible purchase cost for their companies. They determine which products or services are best, choose the suppliers of the product or service, negotiate the lowest offered prices and ensure that the correct amount of the product or service is received at the appropriate time. In order to accomplish their assignments and tasks successfully they have to do market research and customer surveys, identify suppliers, and assess market demand for products and materials. To assist them in their search for getting right information they review catalogues, brochures, price lists, magazine, journal, company publications, company annual reports and directories.

When all the necessary information is gathered, they place orders and contracts with suppliers that meet the requirements of the company. Purchasing agents often work

Reactive Capability

Reactive capability specifies identification, classification and categorisation of interest or problem domain. Its key steps are recognising domains, defining domain boundaries, and defining the underlying approach.

Communication Capability

The communication capability has the ability to check, receive and forward messages of various types, depending on interest domain with common understanding of the scope of the domain and the relationship to other domains.

7.4.2 Best approaches to domain knowledge analysis

Goal: Analyse relevance of input domain knowledge analysis

Sub-goal (1) Knowledge for understanding the subject area

The agent has to learn sufficient knowledge and information about the subject area to perform problem solving and make good decisions to solve a particular problem. To perform domain knowledge analysis, the agent gathers information from whatever sources of information are available: these include important facts or rules that are widely known by the domain experts, principles, business processes, analysis techniques, and how any technology works.

Sub-plan **Seek to understand views, decisions or actions**

(a) Name and select the domain.

(b) Every kind of information that is related to the given domain must be identified, obtained and classified for application.

(c) Summarise the information found during domain analysis.

(d) Describe the meanings of all terms and terminology used in the domain with special meanings, to be able to communicate with users and customers.

(e) Analyse the problems and solutions of the interest area.

(f) For each kind of knowledge and information source, there should be a good technique to explore it.

(g) Effective advice and good decision for specific planning.

Rules

- The knowledge input to a domain may be divided into two distinct classes: problem specification and advice for better solutions to achieve the goals.
- If a constraint may be part of the problem specification, then the agent needs new advice from a domain expert.
- When adding more explicit domain knowledge to a problem specification, the size of the specification will be increased to find more solutions.

Actions

- Avoid situations such as lack of direction while performing an activity, lack of an organised procedure of steps to be performed, lack of confidence in domain language and problems sorting out relevant information from the domain.
- Search for new methods or for people who can provide different kinds of information and knowledge.
- Review evaluation and progress of activity.
- Find a new participant for the role.
- Find good quality and structure of document.

Example **Price determination**

Buyers and sellers communicate information through price, and an exchange of a product takes place when the price is agreed. They determine price by market demand and quantity of supply: an increase in the price of a good is associated with a fall in the quantity demanded and a decrease in the quantity supplied. The equilibrium price is established at the point where the quantities supplied and demanded are equal. At the equilibrium price the market is "cleared". When either demand or supply shifts, the equilibrium price will change.

Sub-goal (2) Define the taxonomy of an organisation

An agent can use the organisation's taxonomy. A taxonomy is a set of terms used to categorise and describe an organisation's information. Taxonomies classify and structure organisational knowledge. They are based on an analysis of business activities and classify resources by the business functions they document. The benefits

of using a taxonomy include avoiding unrelated searching, saving time and seeing related topics presented in context.

Sub-plan **Organise and design a taxonomic database of an organisation**

(a) Understand information and data and their relation.

(b) Retrieve information and data by keywords or taxonomic identifiers.

(c) Understand the terminology used in the organisation.

(d) Use a catalogue to provide a conceptual framework for discussion, analysis, or information retrieval.

(f) Divide information into ordered groups or categories

Rules

- The more precisely the taxonomy matches the users' subject needs, the less time need be spent searching for the best access point in a taxonomy, allowing more time to use the information productively.
- Objectives of building a taxonomy:
  - What is the subject area of the domain that the taxonomy can cover?
  - What information can be retrieve by queries using the taxonomy?
  - Who are the users of the taxonomy?
  - How will the taxonomy be used?
- If defining the taxonomy of entities in a domain that consists of basic classes, first define the sub-types of these classes.
- Gather terms and terminology from the domain.
- Define preferred terms, group preferred terms.
- Associative links with related database.
- Testing.
- The quality of a taxonomy includes: manageability, performance, reliability, security, integrity and usability.

Action

- Understand information and translate knowledge into new contexts.
- Determine what information is needed and identify the appropriate resources necessary to achieve the goal.
- Observe other design requirements of the taxonomy.

- Consider any issues related to the database.

Example

Computerised inventory control provides important information about each inventory item that can be practically managed in the supply chain to keep track of receipts, issues and adjustments. Inventory control can make order recommendations when the quantity of an item falls below a specified level. Inventory control can deal with outgoing orders, incoming stock, backorders, stock among one or many warehouses and store locations. The system can produce a variety of reports including stock, overstock, count worksheets, sales analysis, and perpetual inventory report.

Records management under a computerised system uses code numbers that correspond to specific items. Each item in the inventory is coded, and any adjustment made to the item is effected through use of the items' code numbers. Essentially, either a continuous or a fixed inventory monitoring system is used in most inventory control procedures. Inventory control is useful for management with known demand, price lists, continuous delivery, batch delivery and use until stock runout.

Sub-goal (3) Information Mapping

Information Mapping is a method for presenting information so that is easy to read and understand. An agent needs to do information mapping to support the organisation, leverage knowledge and communicate to improve performance. Many organizations are facing difficult knowledge-related issues that are impacting their business performance. Information management is a way of thinking and communicating in which agents approach content and content users with a set of systematic principles and techniques to ensure that the content can be readily used. It helps discover location, value, and ownership, and helps identify the roles and expertise of people, to identify constraints to the flow of knowledge, and to highlight opportunities to leverage existing knowledge. It places a map over the data to reveal multiple paths to multiple domains.

Sub-plan **How to approach information mapping**

(a) The agent should consider the following steps for mapping information:

- What types of information will be gathered and for what purpose?
- What will agents do with it?
- How will they communicate it and to whom? Identify what is needed in the subject area and/or an organisation, collect and analyse information about workplace, participants and profile.
- What can happen next?
- Who knows whom and how can we find out?

(b) Access the information and organisation requirements.

(c) Analyse the information type and subject matter and categorise it according to the purpose of the audience or organisation.

(d) Create standardised information modules that contain one clear purpose.

Rules

- Identify and locate knowledge in different forms: tacit and explicit formal and informal, internal and external, codified and personalised.
- Consider the organisation's culture and objectives.
- Understand that knowledge is temporary; it can be changed by time and environment.
- Highlight ideas of expertise and advice to improve knowledge sharing.

Action

- Collect documents, files, directories, relationships.
- Look at contact addresses, staff database, library, transactions, helpdesks, department website, internet.
- Conduct interviews and prepare questionnaires for target audience.
- Observe the performance progress.
- Query for information and data.

Example

The purchasing department wants to analyse inventory data by location, so developers will optimise the database to sort and summarise items and product information and data by region, state wide, city and locations of stores. The purchasing department can

then query and analyse monthly sales data to determine which products are in more demand in the market in each store by location or by seasonal and customer demands. The sales manager can create a summary report that lists total sales by region, state and city as well as sales by stores and sales by representative. She can analyse the data about a certain city for the top-performing product in the current financial year and compare with last year.

Order cancellation is a critical issue for the sales manager, especially if the order is cancelled at the last minute. She must find out why and how the cancellation happens. She would have to obtain a different set of reports to investigate open issues with the customer support team. However, the cancellation may not have been caused by the customer support team, but by some unrelated business dynamic in the company.

7.5 Knowledge Filtering Agent

A knowledge filtering agent filters the usable knowledge from the domain knowledge analysis agent, deciding which knowledge to retain or reject. Relevant knowledge is retained, other knowledge is rejected. If the knowledge filtering agent does not accept knowledge or cannot find relevant knowledge, the result is fed back to the domain knowledge analysis agent and knowledge accumulation begins again. Sometimes knowledge can be transferred directly to the knowledge consolidation activity (Maung, 2003a).

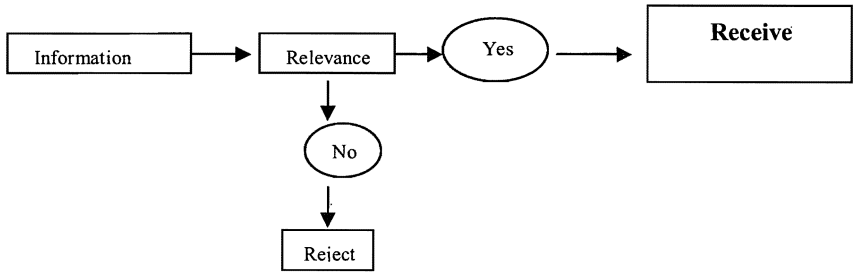


Figure 7-7. Filtering knowledge (Godbout, 1996)

The task is to select or filter information in order to make it relevant to the organization. Figure 7-7 describes the knowledge filtering process. If information is relevant, it is retained or memorized in the knowledge base. If information is not relevant, it is rejected or ignored (Godbout 1996).

Knowledge filtering transforms information into useful knowledge and puts it in the grasp of those who need it.

Example:

A personal agent (PA) (Expert) seeks information on a specific topic of interest. Short of reading an entire article, how can she know whether this article, among thousands of others, is the one she should spend time reading? Knowledge filtering is a dynamic process of managing the creation, distribution, and application of information for specific goals.

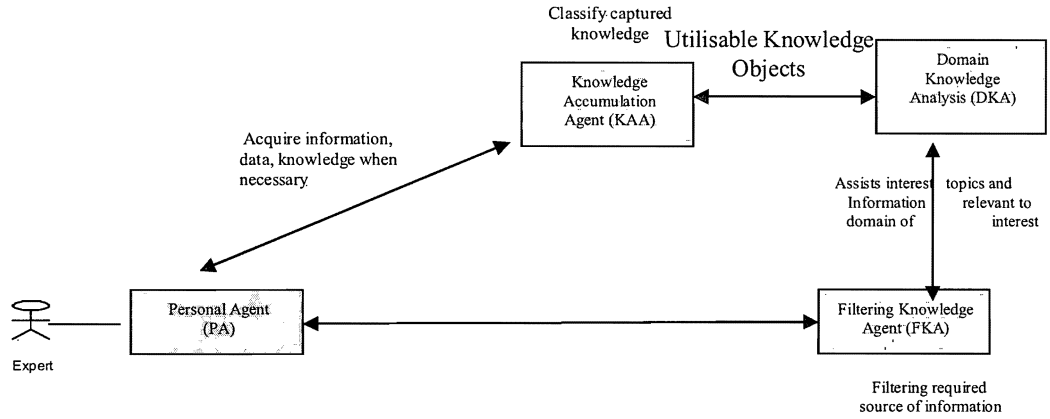


Figure 7-8 Process of Knowledge Filtering Agent (KFA)

Figure 7-8 illustrates how the personal agent (PA) can access information entities that can be relevant or non-relevant to a specific interest. The importance of information is also reflected to the PA, and she can use different approaches to assess the relevance of information entities in context.

The knowledge filtering agent searches for relevant information from the domain knowledge analysis and knowledge accumulation agents with specific objectives of interest.

Planning Capability

The plan for relevant information, data and sources about subject area of interest.

Reactive Capability

Check the plan before making a decision.

Communication capability
Communicate with people involved in the process.

7.5.1 Beliefs of sources about filtering knowledge

Knowledge filtering transforms information into useful knowledge and puts it in the grasp of those in need. It is concerned with determining the information relevant to the agent. The representation of the agent's information need may consist of a set of possible significances by agent profile. Another way of considering the agent profile is to consider it as a description of the agent's interests.

When an agent decides to activate filtering, she believes that the filtered knowledge objects are accurate and relevant to the area of interest to achieve particular goals. The agent has identified the source prior to filtering. Sources may include manuscripts, procedures, research reports, sales information, product information, catalogues, documents, internet, or some combination. The object of filtering is to transform source information into more useful knowledge.

The agent focuses on the source of the material in a specific manner; often it is for a different purpose than originally intended. It is important to identify experts as well as the intended audience. In the next step, the agent determines what information may be in need of intensification through further proof, examination, explanation, graphic and multimedia, and so on. Source material often lacks practical how-to information and perspectives from real-world users. Removing irrelevant, unacceptably complex, or mysterious information can reduce the volume of information to be accessed by the agent as concrete information. This information may be incorporated with more information depending on the agent's need for its particular goals.

7.5.2 Beliefs of best ways for filtering knowledge

Goal: A good knowledge filtering process

Sub-plan (1) Role Factor

The responsibility of the person as an individual or in an organisation who can advise, supervise, manage and making a decision, depending on the intended audience, particular purposes.

Rule ◘ The agent finds role x of the person for relevant information, if x provides the information that the agent needs, then accept it, otherwise the agent should find a role y to achieve the particular goals.

Action ◘ Find the person with relevant skill and qualification.

Example

The role of the purchasing department

The purchasing department provides the best possible service to its own organisation while abiding by and assuring compliance with all the rules and regulations. The primary objective is to buy the right products or services of the right quality, in the right quantity, at the right prices, from the right suppliers (source), at the right time. The role of purchasing is to meet the demands of its customers while incorporating new procedures, technologies and industry practices. It is responsible for:

- reviewing appropriate funding, the quality of product and existing obligation,
- ensuring that all the purchases are in agreement with current status, regulations, rules and policies,
- creating, issuing, accepting and reviewing informal and formal quotations from customers,
- purchasing from qualified suppliers with good reputations

Sub-plan (2) Time Management

Knowledge artefacts have a life cycle. A knowledge artefact will best serve its purpose at particular times. Situating the artefact in the proper step of its life cycle will establish its time relevance (Godbout, 1996). Knowledge can vary over time (Maung, 2003a).

Rules ◘ Remembering
◘ Priority
◘ Enthusiasm

Actions ◘ Remember things to do at the right time, write them down in a time table.

- Do the most important things first in a list of things to do.
- Start with good motivation to continue doing something.

Example **(1) Timing of Purchases**

In the timing of purchases, the purchasing department is interested in assuring that there is an adequate supply of products in stock at optimal prices and meeting quality and service requirements. If demand for a product increases, a temporary shortage may develop until production capacity has increased to satisfy the increased level of demand. Time is most important as an issue when a purchase is made in a market that tends to be unstable. The purchasing department must carefully observe and analyse market conditions if they hope to satisfy their price and supply objectives.

(2) Just-In-Time (JIT) purchasing

Just-In-Time (JIT) purchasing refers to the purchase of goods or material just prior to demand or use. Timely delivery of quality products is crucial in this environment. The company carefully selects suppliers with good reputations. If demand is high, or the order is late in arriving, the company may run out of product in the warehouse, which could stop production or miss order ship dates. JIT purchasing depends on the supplier to provide products on time and in amounts required for daily use, thereby reducing in-stock inventories and associated costs.

Sub-plan (3) Experience Factor

A knowledge artefact can be varied depending on a person's experience. The experience factor is associated with the person's previous problems, suffering, lessons learned and interests. Experience factors include work experience, field experience and practical experience.

Rules
- Gaining experience by solving problems and mistakes.
- Acquiring new knowledge and skills.
- Continuing to learn and making a difference to build knowledge

Actions
- Going to training, taking courses, learning from hands-on experience.

Example **Experience in purchasing**

Purchasing experience implies the possession and application of a good working knowledge of purchasing methods, regulations, policies, procedures and requirements. The qualifying experience includes authorisations for purchases, requisitions, invoices, purchase orders, statewide central purchasing lists for validity and accuracy. Experience in preparing and submitting requisitions for purchasing where the work involved includes: gathering information regarding the desired product and alternatives by gathering brochures and discussing requirements with requestors and vendors; obtaining information regarding prices and/or obtaining quotations; writing requisitions; preparing requisitions for submission for purchasing; and demonstrating an understanding of purchasing policies, procedures and requirements.

Sub-plan (4) Objectives and Policies

Company objectives and policies dictate the nature of the work to be performed and provide guidelines to determine whether performance is satisfactory. They communicate expected performance clearly. Results are the outcomes of activities towards an objective, the effects on actions taken.

Sub-plan: Objectives and policies measure work and performance of activities to reach the goal in limited time.

Rules

- Identify work processes and require resources for inputs and reflective outputs (results).
- Objectives should be clear, understandable, measurable, schedules and times should be fixed.
- Set up milestones for activity and progress reports for performance and improvement.
- The human resources department is the source of objectives. They can generate objectives related to other matters. Other departments can issue their own objectives.

Actions

- Review outcomes of work process from employee's work activities.
- Consider what processes are in need of improvement.
- What are the requirements of development and improvement of the intellectual and human resources?
- Outline some measurable standards the work must satisfy. How to

measure results? Modify the necessary action taken if it is needed.

- Specify deadlines, due dates and timetables for work activities.

Example **Purchasing objectives and policies**

From a top managerial perspective, the objectives have been expressed as the acquisition of products: of the right quality, the right quantity, at the right time from the right supplier at the right price. A policy is a statement that describes in very general terms an intended course of action. When the fundamental objectives of an activity have been established, policies are developed to serve as guidelines for making decisions towards achievement of the objectives.

An organisation's policy statement: it aims to actively develop long term business relationships with suppliers to maximise supplier and customer satisfaction. The objectives of policies are aimed at: providing the best quality products and services at the most reasonable prices for customers, ensuring quality of product; suppliers should provide samples of products; the product should be delivered to customer on time.

Sub-plan (5) Physical Representations or Symbols

A physical-representation is our means of communicating our mental material, form of though and type of thinking to another person. Words are symbols and express an idea. Symbols are the most powerful communication tools that have ever existed. Because they have the ability to convey so much meaning, intent and significance in such a compact, immediately recognizable form, the effect that they have is tremendous. But they can convey negative communication as well as positive. Symbols communicate and understand regardless of language.

Rules

- Use symbolic systems: charts, graphs, diagrams and photos.
- Three-dimensional representations are better than two-dimensional representations.
- Colour is better than black and white.
- Animated images are more effective than static images.
- Interactive graphics are better than noninteractive graphics.
- Video clips are better than static images.

- Virtual reality is more effective than animation.

Action

- Monitoring and controlling of performance using graphical representations and two- or three-dimensional representations.

Example

Supply chain management is a critical and challenging activity, especially when managing the partnership or relationship with the supplier. Purchasing must monitor the supplier's progress closely to ensure that desired items are delivered on time. The method of monitoring depends on the lead time or period of performance, complexity, and urgency of the order. When evaluating a supplier's progress, the buyer is interested in actual progress and completion of work. Data about progress may be obtained and be analysed by using charts and graphs.

(a) **Gantt Charts** are a tool that can be used for planning and controlling purchasing activities and deliveries with schedules and time scales.

(b) **CPM (Critical Path Scheduling) and PERT (Program Evaluation and review Technique)** are tools that can be used to manage buying activities, construction projects, and research and development activities. They can represent information about uncertainties faced by the activities responsible for meeting a predetermined time schedule. CPM/PERT network diagrams show time and dependency relationships between the activities that make up the purchasing and delivery of orders.

Sub-plan (6) Positive Feedback (Questionnaire Survey)

Positive feedback is essential to gain optimum benefits. It provides time for understanding to develop on challenging new perspectives, and permits evaluation of knowledge management activities to assess their performance.

Rules

- How many questions and what to ask?
- Understand how to ask important questions to avoid bias.
- Ensure that the right target group are asked for the right questions.

- Define the methods of survey: (examples: email, online, telephone, in-person)

Actions

- Understanding target groups and surveys.
- Advantages and disadvantages of surveys.
- Cost of survey.
- Determine the survey sample (interview).
- Design interviewing methods (personal, mail, telephone, email)
- Create and test the questionnaire.
- Conduct interviews, analyse the data to produce the reports.

Example (1) Market Research

Market Research is any activity aimed at understanding the behaviour of consumers (whether they are industrial (companies) or end users (consumers)) in a certain market. Managers need information in order to introduce new products and services that create value in the mind of the customer. But the perception of value is a subjective one, and what customers value this year may be quite different from what they value next year. Data must be collected and analysed. The goal of market research is to provide the facts and direction that managers need to make their more important marketing decisions. Market research conducts focus groups, surveys, online research, strategic analysis, and consulting for businesses.

Example (2) Purchase good quality of product from potential suppliers

Purchasing responsibility for quality management is a major component in supply chain management. If a product is of poor quality, it will lead directly to costly difficulties that reduce profit, and will lose customers. To avoid these problems, the following points must be considered before buying a product.

(a) Product Testing: The purchasing department must select competent and cooperative suppliers in the first place. Before purchasing items from the suppliers, one practical approach to determining the suppliers' potential quality of products is by testing or using them. Product testing determines that a potential supplier meets the buyer's quality needs and where possible, compares quality levels of several different

suppliers. This allows preparation of a list of qualified suppliers which the buyer can compare on the basis of the quality and cost.

(b) Proposal Analysis: The next step in assessing a potential supplier's quality capabilities is analysing the proposal. Bidders indicate in their proposals, either directly or indirectly, how they intend to comply with the quality requirements of the purchaser. The buyer must be especially alert in detecting areas of misinterpretation or possible areas of overemphasis by the bidder that could result in excessive costs (Dobler, et al 1990).

(c) Capability Survey: The buyer analyses an onsite capability survey for evaluating quality capabilities because of time and expense involved.

7.6 Knowledge Interpretation Agent

A knowledge interpretation agent understands and resolves the filtered knowledge objects after knowledge filtering activities. Webster defines **interpretation** as explaining or telling the ***meaning*** of something and presenting it in understandable terms. Another way to describe **interpretation** is as the bridge between **observation** and **application.** Knowledge has been frequently described as "justified true belief" (Nonaka, 1990), a belief held by an individual that is both true and for which they have some justification. The justification of belief is based on internal considerations concerning the qualities of the function producing the belief. "True" may be interpreted as a belief, it is not justified.

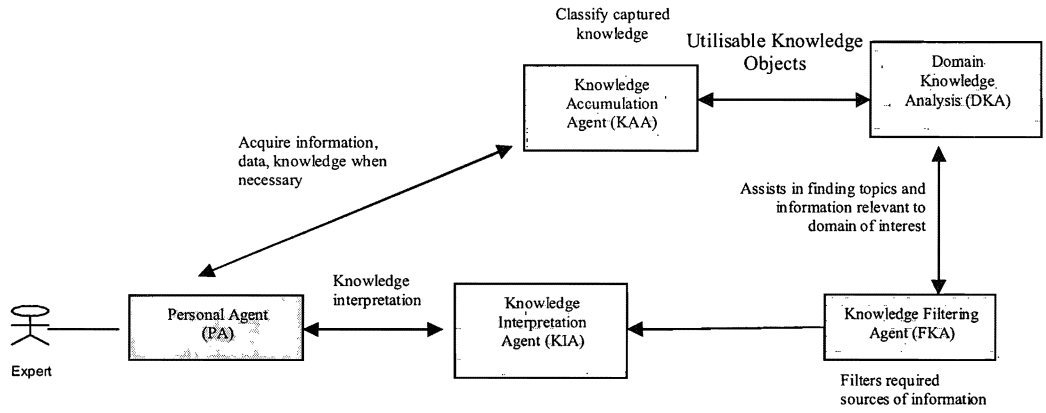


Figure 7-9 Process of knowledge interpretation agent

Planning Capability

Identify the problem(s) and make categories or associations and relationships. Processes need to be planned carefully if they are to be efficient. Planning requires record keeping, progress, milestones and decision-making processes in a form which is communicable to all.

Reactive Capability

Belief in decision making on the basis of truth. Trust is one subject's willingness to be vulnerable to the actions of another subject, based on the expectation that the other will behave in a way that is important for the agent.

Communication Capability

Awareness and understanding of specific filtered knowledge objects. Poor communication can result in loss of information, incurring organisational problems. A good flow of accurate information, instructions and feedback is needed by the system.

7.6.1 Beliefs of best knowledge interpretation process

Goal: Effective good knowledge interpretation process

Sub-plan **Attempt to put the information in perspective**

Collect all the data of interest and information from the relevant resources and organise comments into similar categories, e.g., suggestions, concerns, strengths, weaknesses, similar experiences and recommendations. Categorise suggestions, concerns and comments and attempt to identify patterns, or associations and relationships. Consider recommendations to improve the work activity or performance and recommendations in a report and associate interpretations to justify conclusion or recommendations.

Rules

- Trust
- Responsibility

Actions

- Response to entail previous listening to questions, openness, willingness to understand and confront others' commitments.

- Attribution of responsibility can be anticipatory, and then it can be a pattern for accountability.

Example

Product strategies establish the basic task for the supply chain, including the determination of the priorities, with regard to product objectives, needed to meet customer requirements and to beat competitors in business. Differentiated strategies, with regard to time, cost, and product innovation, impose different requirements on the supply chain. The main function of supply chain might to be provide goods and/or services that are required by customers and to provide products at suitable times and places with appropriate quality Purchasing planning is important, although it is simply deciding what to do, how to do it, when to do it, and who to do it. Purchasing officers must collect information and monitor factors in supply markets and the external environment of the organisation. It will be necessary to investigate what new materials are being developed, what changes in supply and demand can be expected, and what price trends can be expected. Monitor the progress and performance of the department and of the staff to check and feedback from customer requirements.

Sub-plan **Communication and Listening Skills**

Effective communication is critical to the success of knowledge interpretation and requires active listening skills. Effective questioning techniques can expand knowledge and bring out new ideas more clearly and effectively by different methods of communication. It is important to determine the right target group for communication. Skilled dialogues with demanding focus groups, particularly those from the field of interest and attention, are valuable.

Rules

- Concentration
- Understanding
- Acceptance
- Summaries
- Questions

- Provide positive feedback

Actions

- Make communication positive, clear, and specific.
- Ask questions to clarify issues.
- Recognize that each individual sees things from a different point of view.
- Learn to listen and ask questions to clarify issues.

Example

To understand its customers, a company must identify their requirements. When customers go to the supermarket to purchase laundry powder, they go there for the convenience of a nearest store and are not necessarily looking for the lowest price. In contrast, a low price is very important to a customer who buys home brand rather than a popular brand. This customer may be willing to tolerate less variety and even purchase family packages as long as prices are low. There are some factors that may be considered: the quantity of the product needed in each lot, the response that will be tolerated by customers, the variety of products and the level of services and the price of the product. Based on current market situations, the purchasing team should consider what kinds of decisions have to be made in order to achieve the sale or product that involves resources, methods and suppliers.

Sub-plan **Focus Groups**

Focus group techniques involve nominal group techniques, Delphi techniques, brainstorming and interview methods. In a focus group, a small group of people discussing a topic or issues.

Rules

- Select the focus group
- Plan and conduct focus group session
- Integrate the focus group
- Select questions and topics to discuss
- Analyse and summarise results

Actions

- Nominal Group Technique (NGT) for small group meetings in which individual judgment can often be effectively pooled:

- Onsite observation for observing, interpreting, and recording to solve problems
- Blackboarding technique for an unstructured approach to generating ideas by which tow or more participants ideas about a problem domain.
- Electronic brainstorming for using computer-aided approach.
- Idea writing for a structured group approach used to develop ideas, explore meaning for clarity and specifying; and produce a report.

Example

Selecting the most appropriate suppliers is an important issue in supply chain management. In today's competitive environment, it is tremendously difficult to successfully produce high-quality, low-cost products without a satisfactory set of suppliers. An important aspect of purchasing is determining the configuration of the supplier base. Many companies are looking to their suppliers to help them achieve a stronger competitive position. The focus group on suppliers is constrained by the quality level of products that can be produced and supplied by the suppliers; the lead time to supply the products; and storage capacity requirements for the suppliers. From the purchasing management's perspective, the long lead time of one supplier is perhaps compensated by the short lead times of other suppliers. A purchaser's mission can help a company to choose an optimal set of suppliers and make allocations based on demand, taking into account quality requirements, restrictions in storage and production capacity, production lead time, and lead time requirements.

Sub-plan **Identify and Structure Questions**

The questions are important for capturing and interpreting knowledge. The questions are structured and in form for use.

Rules

- Multiple-choice questions
- Ranking scale questions
- Dichotomous (yes/no) questions
- Identify key questions

Actions

- Check the questions it is necessary to ask; are they covered in other questions?

- The questions adequately cover the intended area of interest.
- The question wordings are clear and understandable.
- The question format is easy to use and respond to.
- Define the length of questions and the duration of discussion.
- Identify closed questions, primary questions and secondary questions.

Example

Companies and supply chain managers should be aware of customer demands on survey and feedback from the market. The forecast of demand forms the basis for all strategic planning in decisions in a supply chain. The first step a manager takes is to forecast what customer demand will be. Long-term forecasts are usually less accurate that short-term forecasts. Some factors that are important for demand forecasts are past demand, lead times of products, price discounts, time, historical demand and actions that competitors have taken in comparable situations.

7.7 Knowledge Consolidation Agent

A knowledge consolidation agent reinforces embedded knowledge to entrench interpreted knowledge objects. It classifies interpreted knowledge according to which events relate to the categories, and the main objects of interest.

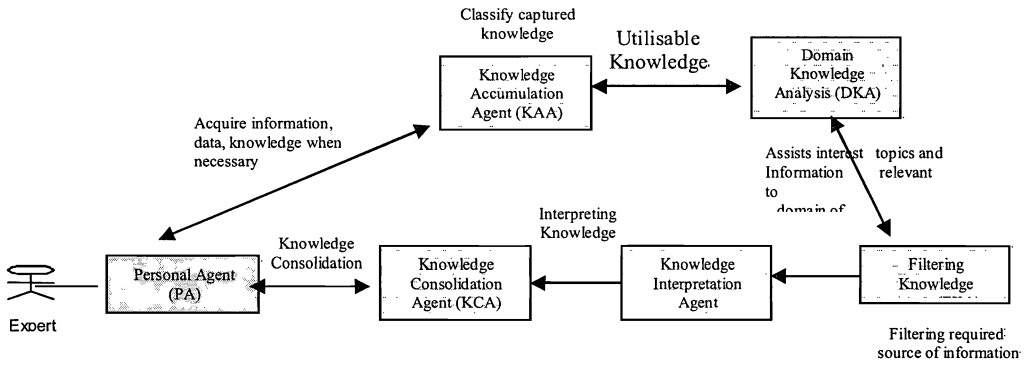


Figure 7-10 Process of Knowledge Consolidation Agent (KCA)

Planning Capability

Methods of collective reflection on success and failure, and sharing in the consolidation of knowledge.

Reactive Capability

Management of changing requirements and innovative new methods of retaining knowledge.

Communication Capability

Proactive and reactive methods for retaining collective knowledge.

Sub plan **Observing and Analysing**

Rule
- Identify problems to solve to provide the needed level of satisfaction.

Action
- Observation and analysis are accomplished on an individual basis and communicated in working meeting or impromptu encounter.
- New methods, ideas, concepts, approaches to implement the progress.
- Consolidated knowledge is facilitated by a collective effort to ensure that failure does not recur for the same situations and that success is possible.

Example

An aircraft's early life is dominated by its engineering and maintenance requirements. Its flight pattern for months ahead is planned to ensure it is back at base as required by its maintenance schedule. In practice, its flight program is so well organised that only in exceptional circumstances does an aircraft even come close to the legally permitted limits on the number of flying hours between overhauls. An aircraft's working life is punctuated by a rigid succession of maintenance schedules based on the number of hours it has flown. These checks are frequent and become progressively more thorough as the air miles mount. Some schedule checks are: pre-flight inspection, daily check, every 150 flying hours check, every 1000 flying hours check, every 18 months and after 24,000 flying hours (Hill, 1993).

Sub-plan **Building Trust for Knowledge Sharing**

Rule
- Activities to build trust

Actions ◘ Encourage participation in team social activities, induction programs job rotation, seminar, workshop, milestone celebrations, face-to-face communications, video conferencing.

Example

Quality of product and services is an important concern to both the organisation and its customers. Customer confidence in the level of quality will have a significant impact on a company in terms of future levels of demand and the long-term success of the business. Customer requirements are at the core of quality conformance. Requirements originate with the customer, result in an understanding and agreement on the specification and necessitate the consistent meeting of these needs.

In 1995, Philip Morris recalled all its Marlboro cigarettes from the US market fearing they could harm smokers' health. A batch of filters had become contaminated with a chemical that caused coughing and sneezing. Philip Morris went to great lengths (including full page newspaper advertisements and a free inquiry service). The recall cost $200m and was believed to contribute to the increase in Marlboro's market share that followed (Hill, 1993).

7.8 Knowledge Refinement Agent

A knowledge refinement agent modifies and updates the consolidated knowledge objects in organisational memory into a form suitable for use in business activities.

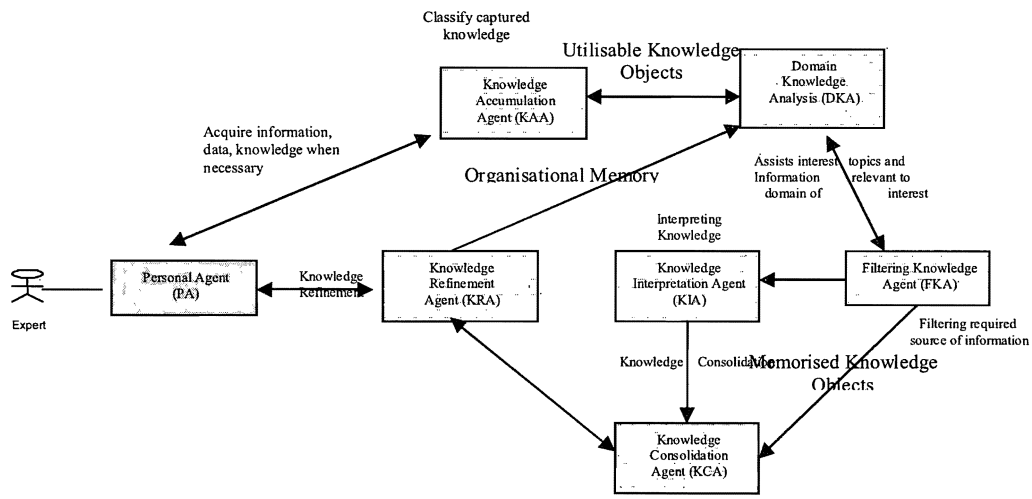


Figure 7-11 Process with knowledge refinement agent

Planning Capability
Identifying and articulating similarities and differences among items.

Reactive Capability

Classifying and grouping things into definable categories on the basis of their attributes.

Communication Capability

Identifying and articulating the underlying theme or general pattern of information or observations.

Sub plan **Analysing Errors**

Rules

- Identify errors.
- Errors can be "overtly idiosyncratic" or "covertly idiosyncratic".
- Errors are classified.
- Errors are explained.
- Errors are evaluated.
- Errors are prevented or correct.

Actions

- Identify the location of errors and their characteristics, referring to the nature of the problem.
- Organise a wide range of typical errors classified by knowledge sources, which can give useful hints when developing a system.
- Identify useful techniques to tackle errors.
- Avoid incomplete application of rules that can involve a failure to analyse errors.
- Define error analysis rules that involve explanation of errors, what terms would the expert prefer to express, what formalism and implementations are suitable for encapsulation, examples or case studies, comments and feedback.

Example

Managing inventory control is a key operations task and helps operations to run smoothly and efficiently to effect the supply of goods and services to customers. The

important issue is that the amount of inventory required will depend upon the relative rates of demand and supply. The level of inventory impacts profit levels, inventory cost structures and corporate issues around service levels, lead times and supplier relations. The key issues to be addressed in the management of inventory are what and how much to hold and to order. The level of inventory is a consequence of a company's day-to-day activities, but is not usually specifically addressed each time these events take place.

Sub plan **Case Based Reasoning**

Rule
- Use generalisations or principles from information or observations.

Actions
- Construct support and build systems of support for assertions.
- Retrieve the most similar cases.
- Reuse the cases to solve the problem.
- Maintain solutions to relevant cases.

Sub plan **Analyse Perspectives**

Rule
- Identify multiple perspectives on an issue and examine the reasons or logic behind each.

Action
- Identify and articulate errors in thinking.

In the next chapter we will describe using software agent to demonstrate EKP model to facilitate the process.

Chapter 8
Implementation

8.1 Implementing the EKP Model

In this chapter, we describe how we implemented the EKP model on a server. Chapter 4 described the concepts of developing the EKP model. Chapter 6 described a method for integrating knowledge management into business process and Chapter 7 described agents that can facilitate the process.

Implementation of the EKP model needs a system architecture and technologies that can support the implementation. There are two sides, the client side and server side. On the server side, we used the Tomcat HTTP server to run a Java program, as shown in Figure 8-1.

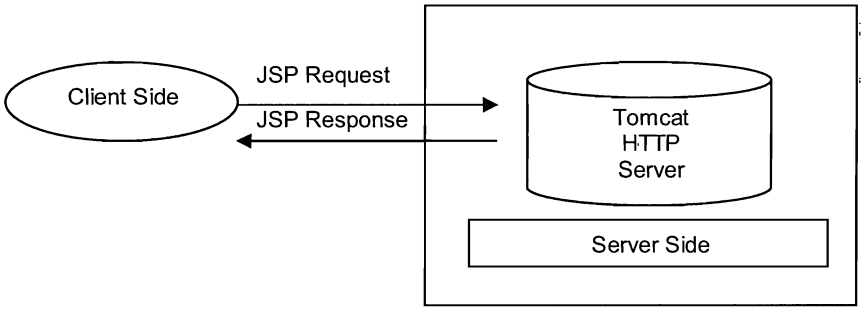


Figure 8-1 Technical structure of the HTTP request handler

The above figure shows how a client request is sent to the HTTP server, which processes the client request and returns a response to the client browser.

8.2 Implementation of the System Components

The implementation of the components of the EKP model is described using the file structure of the HTTP Tomcat webserver shown in Figure 8-2. The system runs on the internet and we can view the graphics. When we click on a box in the "Evolving Knowledge Process (EKP) Model" menu item in the popup menu shown in Figure 8-3, the EKP model will come on the screen, as shown in Figure 8-4. The EKP model has different agents that facilitate the knowledge process. Each agent has its own planning capability, reactive capability and communication capability.

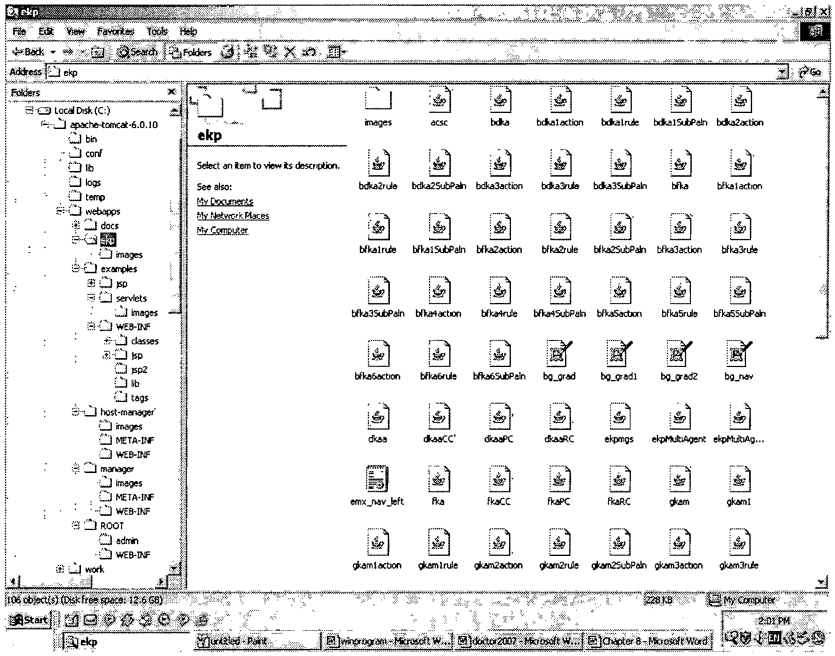


Figure 8-2 the file structure of the HTTP Tomcat webserver

Figure 8-3 shows the main menu of the EKP model. The interaction of EKP agents in charge of producing knowledge object structures the knowledge creation process to provide information when and where it is needed. Each EKP agent uses goals, plans and actions to facilitate its process.

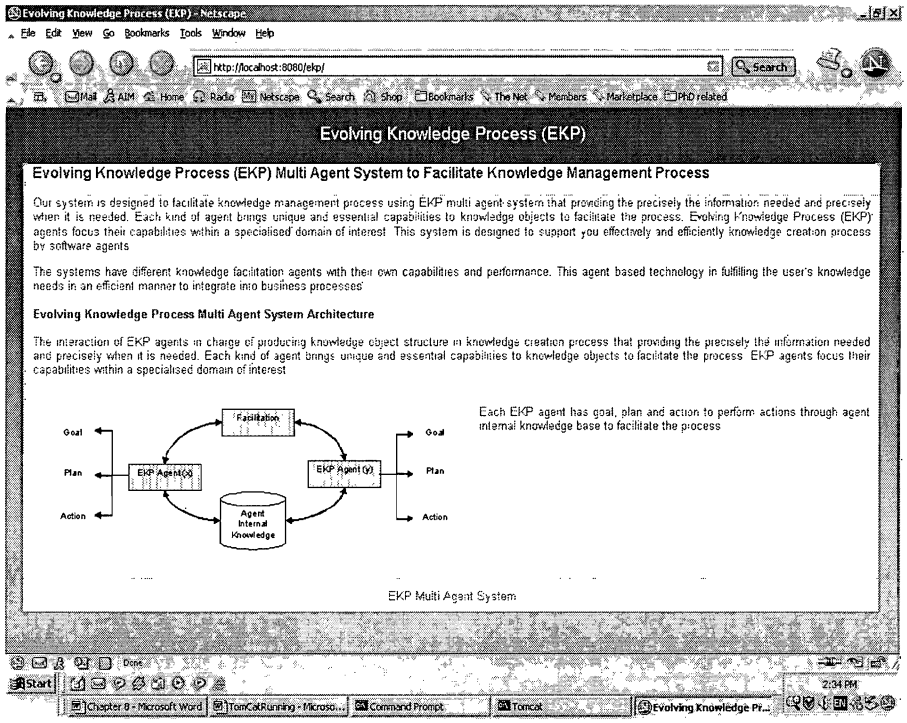


Figure 8-3 Multiagent Systems screen

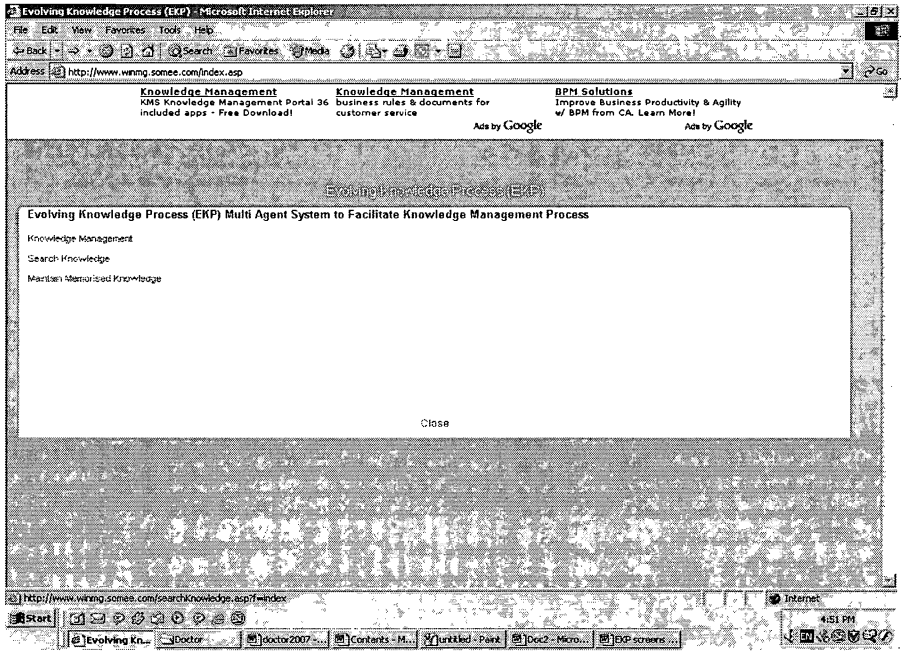


Figure 8-4 Evolving Knowledge Process menu

In Figure 8-4, we illustrate how the EKP model is implemented using software agents. We have three choices: knowledge management, search knowledge and maintain memorised knowledge. The user can select the knowledge management section and

enter information and data. For example, if "The best ways for information gathering" is selected. The screen shown in Figure 8-5 will appear.

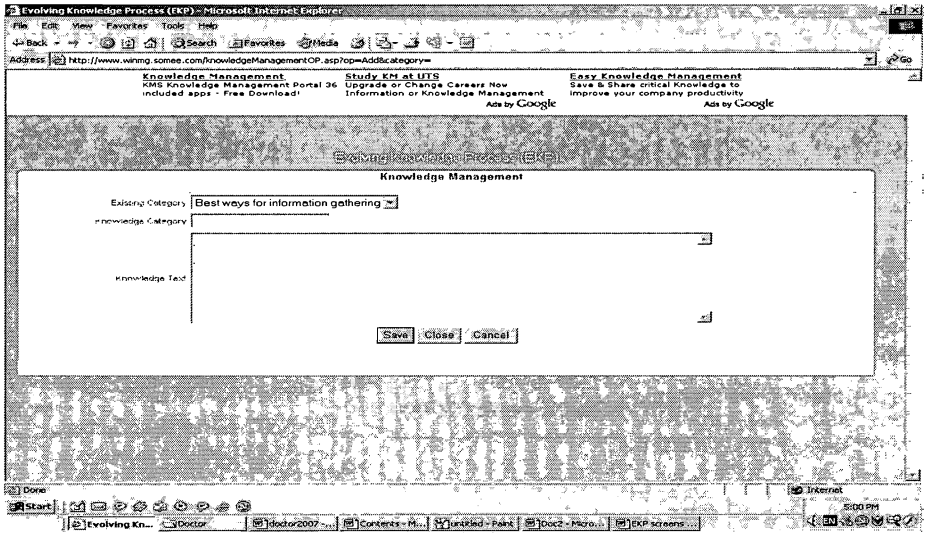


Figure 8-5 Knowledge management screen

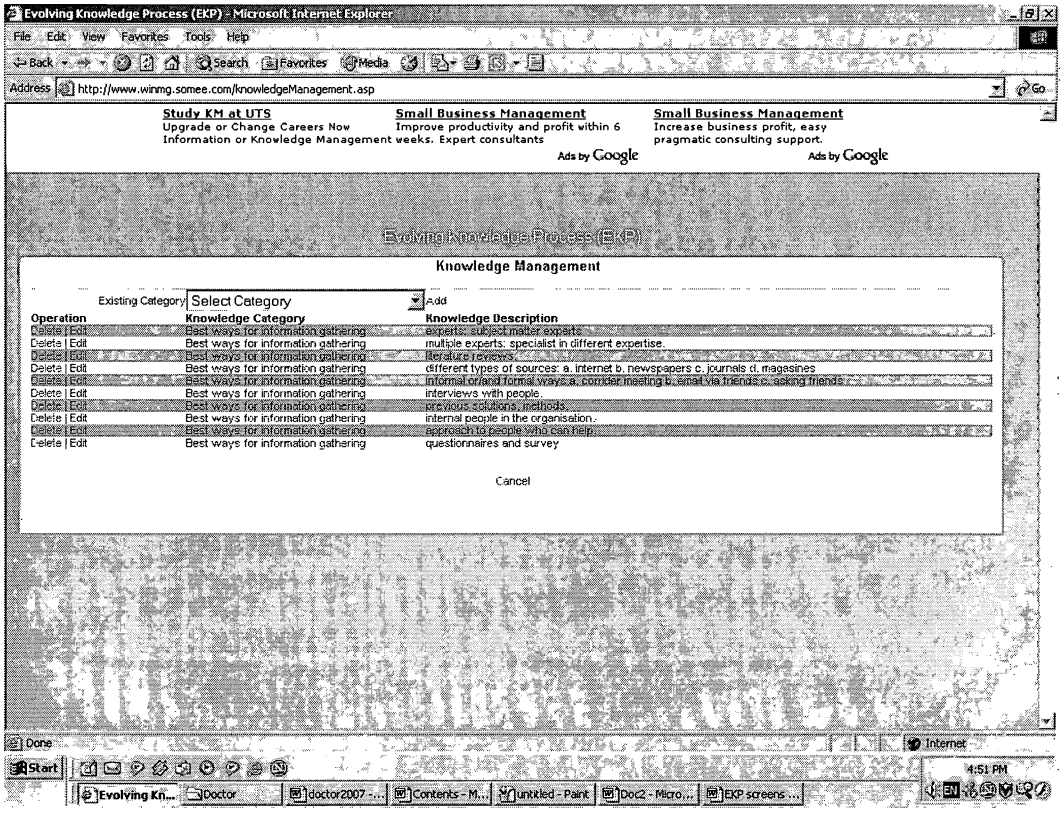


Figure 8-6 Knowledge category and knowledge description screen

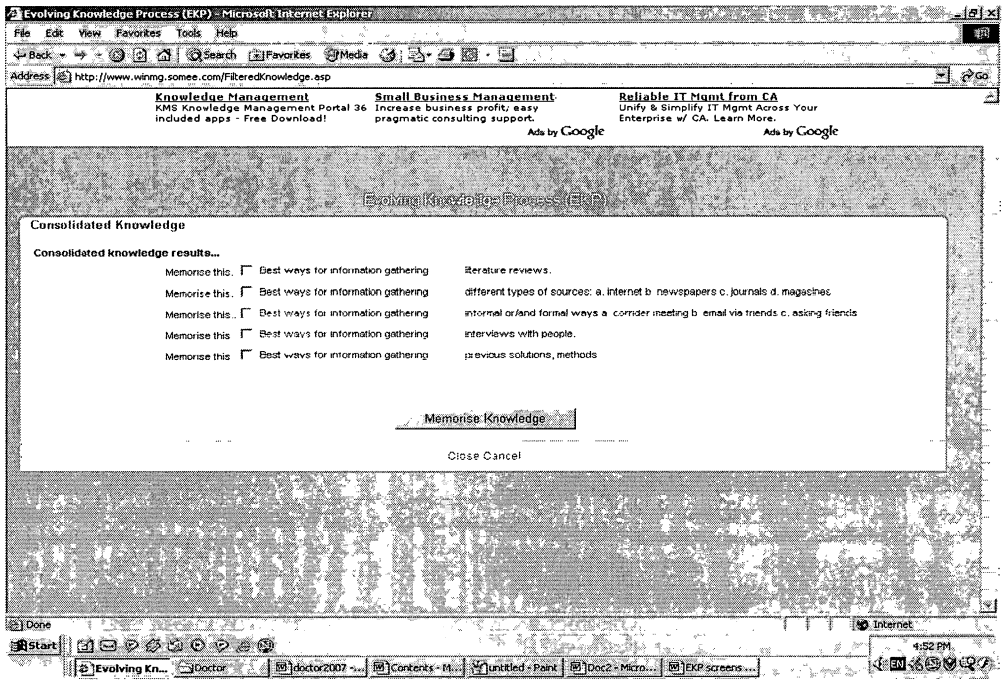


Figure 8-7 Consolidated knowledge screen

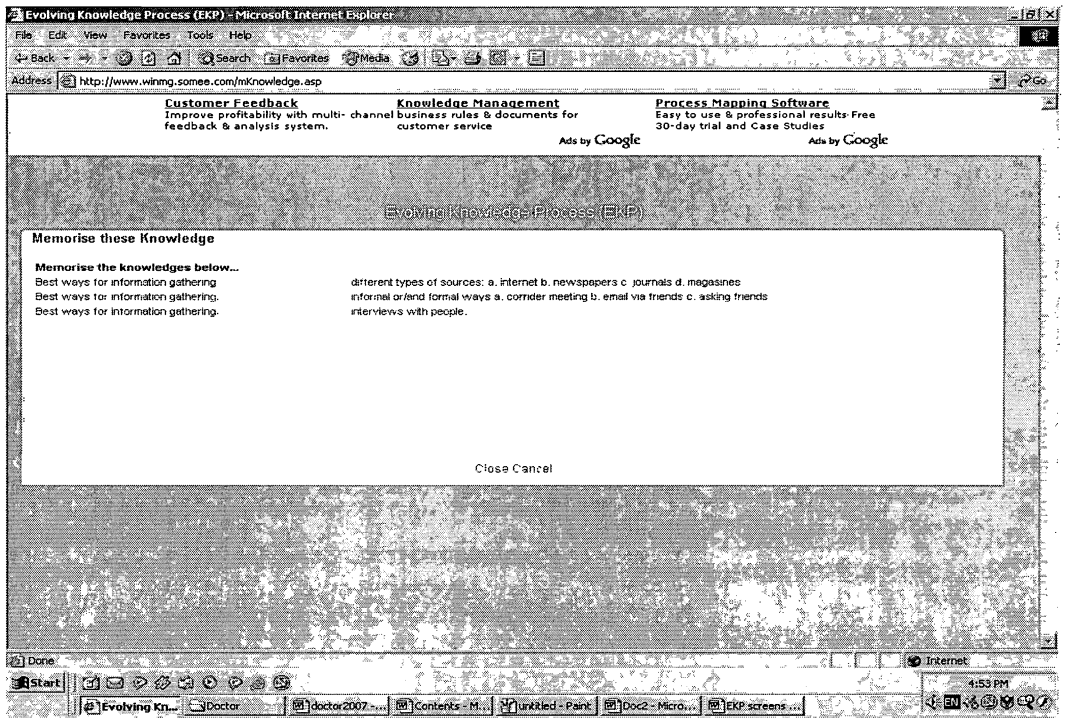


Figure 8-8 Memorised knowledge screen

Figure 8-8 illustrates the best ways to gather information. The software agent facilitates the process and the user can choose as desired.

This chapter has described the implementation of EKP model using software agents.

Chapter 9

Conclusions and Future Work

This chapter summarizes the distinctive features of our solution for integrating knowledge management into business processes. We will also discuss future work.

9.1 Conclusions

As we described in Chapter 2, the literature review, knowledge management has many applications and it is now widely used in consulting firms and in the academic and private sectors. We also discussed the two approaches of theoretical frameworks and practice in knowledge management research. Most research focuses on both theory and practice in business processes but some theories are difficult to apply in business processes because they lack objectivity and generality, as knowledge management methods are usually context dependent and not easily transferred from one organisation to another (Hasan, 2003). Some knowledge management research relating to the most popular strategic change management approaches (Davenport and Prusak, 1997) has emerged in knowledge and information management (Spiegler, 2000). One of the competitive advantages in knowledge management research is the knowledge creation process (Nonaka and Takeuchi, 1995). We are encouraged to present a new solution to the integration of knowledge management into business processes based on Nonaka's knowledge creation process in the form of the evolving knowledge process (EKP) model. This methodology is presented in this thesis. It is discussed in Chapter 3. Our research methodology has the following distinctive features.

9.1.1 Integration of Knowledge Management into Business Processes

We described the research objectives and methodology in this thesis in Chapter 3. We first developed a concrete knowledge model and defined the knowledge activities and resources that occur in the knowledge creation process. We showed the completeness of the process by showing that it corresponds to Nonaka's processes. Second, we discussed how our EKP model could be integrated into business processes. Third, we used software agents to facilitate the integration of knowledge management into

business processes. Finally, we implemented the EKP model using the Java programming language and a hybrid system architecture using the traditional client/server architecture to demonstrate how to facilitate the process.

9.1.2 Implementation of the EKP model using software agents

We used agent technology to design and implement the Evolving Knowledge Process model. A software agent takes autonomous actions in the environment in order to meet its design objectives (Wooldridge and Jennings, 1995). Agents can be collaborative and adaptive. Agents are autonomous as they can perceive the environment and solve problems. Agents are able to act without the intervention of humans or other systems: they have control over both their own internal state, and their behaviour. They are collaborative because they can communicate and interact with other agents to solve problems. They are adaptive because they can apply process knowledge to assist problem solution.

Our EKP agent has three components goals, plans and actions. Each agent has a control subsystem to control planning capability, reactive capability and communication capability. The agent looks for relevant plans, and takes necessary actions (who, where, what, why, when and how =5ws & h). to achieve its goals. Each agent chooses the people who can support the plan with their skills and experience in the specified area of interest. It uses knowledge about what information is needed in the activity, knowledge about the best ways to carry out the activity and knowledge about the best sources for the information needed in the activity to achieve the goals.

9.2 Future Work

Although our evolving knowledge process model is more focussed than Nonaka's model on filling the gap to integrate knowledge management into business process, it is not yet complete. Much work is required in future research.

9.2.1 Developing Integration Methods

Developing new methods for integrating knowledge management into business processes is important and necessary because systems fail and we need practical methods to minimise the risk of such failures. Our methodology is effective as a

knowledge management system in which knowledge is created, transferred and used. It also assists in locating the necessary sources of information and in knowledge transformation and knowledge sharing. It can identify potential improvements of business processes and use diagnostics to improve the processes.

We discussed a methodology in Chapter 3, a model of knowledge management in Chapter 4, and a method for integrating knowledge management into business processes in Chapter 6, so that the EKP model will be more useful.

9.2.2 Using Software Agents for Implementation

Using and implementing software agents is necessary to demonstrate the knowledge model online and to facilitate the KM process. The user agent needs programming to develop the model.

9.3 Research View

In our research, we have completed the development of a knowledge process model, a methodology of integration, and prepared a software agent architecture, components, development and implementation, using text, diagrams, tables, Java source code and we have demonstrated our multiagent architecture online. We have thus contributed to the progress of research that will provide more practical approaches to knowledge management research in the private sector, government and academia.

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1. Maung, W. (2005) Knowledge Management Facilitates Virtual Learning Processes, *Third International Conference on Computer Applications* (ICCA 2005), University of Computer Studies, Yangon, Myanmar, 9–10 March, 2005.

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Appendix

Source Codes

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:800px;dialogHeight:400px;");
}

</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName"> <strong>Evolving Knowledge Process (EKP) Multi Agent System to
    Facilitate Knowledge Management Process</strong>  </div>
<div align = "center">
    <div id="content1">
      <div class="feature">
        <div align="justify"> <a href="knowledgeManagement.asp" title="Knowledge Management" >
            Knowledge Management</a><br>
          <br>
        <a href="searchKnowledge.asp?f=index" title="Search Knowledge">Search Knowledge</a><br
            ><br>
        <a href="memorisedKnowledgeManagement.asp?f=index" title="Maintain Memorised
            Knowledge">Maintain Memorised Knowledge</a>
</div>
    </div>

    </div>
  </div>
  <div id="siteInfo">
    <div align="center"><a href=""  target = "popup" onClick="javascript:self.close(); return
        false;">Close</a>
    </div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:800px;dialogHeight:400px;");
}

</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName"> <strong>Evolving Knowledge Process (EKP) Multi Agent System to
    Facilitate Knowledge Management Process</strong>  </div>
<div align = "center">
    <div id="content1">
      <div class="feature">
        <div align="justify"> <a href="knowledgeManagement.asp" title="Knowledge Management" >
            Knowledge Management</a><br>
          <br>
        <a href="searchKnowledge.asp?f=index" title="Search Knowledge">Search Knowledge</a><br
            ><br>
        <a href="memorisedKnowledgeManagement.asp?f=index" title="Maintain Memorised
            Knowledge">Maintain Memorised Knowledge</a>
</div>
    </div>

    </div>
  </div>
  <div id="siteInfo">
    <div align="center"><a href=""  target = "popup" onClick="javascript:self.close(); return
        false;">Close</a>
    </div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<%
dim txtSearchKnowledge, filePath,connectionString,conn,rsKnowledge,sqlString,sqlStringM,
    rsMKnowledge
dim ismFound
'txtSearchKnowledge = request.form("txtSearchKnowledge")
filePath = server.MapPath("ekp.mdb")
set conn = Server.CreateObject("ADODB.Connection")
set rsKnowledge = Server.CreateObject("ADODB.Recordset")
connectionString = "Provider=Microsoft.Jet.OLEDB.4.0;User Id=Admin;Password=;Data Source="+
    filePath+";Persist Security Info=False"
conn.connectionString = connectionString
conn.open
txtSearchKnowledge=""
isFound = False
ismFound = false
'Response.Write(Request.Form("knowledge").Count)
for i=1 to Request.Form("knowledge").Count
    isFound = true
    txtSearchKnowledge = txtSearchKnowledge + "," + Request.Form("knowledge")(i)
'   Response.Write(Request.Form("knowledge")(i) & "<br />")
next
if isFound then
txtSearchKnowledge = right(txtSearchKnowledge,len(txtSearchKnowledge)-1)
end if
ismFound = False
'response.End()
for i=1 to Request.Form("mknowledge").Count
    ismFound = true
    txtMSearchKnowledge = txtMSearchKnowledge + "," + Request.Form("mknowledge")(i)+""
next

if ismFound then
txtMSearchKnowledge = right(txtMSearchKnowledge,len(txtMSearchKnowledge)-1)
end if

'response.Write(txtMSearchKnowledge+","+txtSearchKnowledge)

if (txtSearchKnowledge <> "") then
    txtSearchKnowledge = txtSearchKnowledge
end if

if (txtMSearchKnowledge <> "" and txtSearchKnowledge <> "") then
    txtSearchKnowledge = txtSearchKnowledge + ","+ txtMSearchKnowledge
end if

if (txtMSearchKnowledge <> "" and txtSearchKnowledge = "") then
    txtSearchKnowledge =  txtMSearchKnowledge
end if

if isFound = true and ismFound = true then
txtSearchKnowledge = txtSearchKnowledge + ","+ txtMSearchKnowledge
end if

if isFound = false and ismFound =  false then
txtSearchKnowledge = "0"
elseif (isFound =true and ismFound = true) then
txtSearchKnowledge = txtSearchKnowledge + ","+ txtMSearchKnowledge
elseif (isFound = true) then
    txtSearchKnowledge = txtSearchKnowledge
else
txtSearchKnowledge = txtMSearchKnowledge
end if


sqlString = "select * from knowledgeDetails where id in (" + txtSearchKnowledge +")"
'response.Write(sqlString)
'response.End()
'sqlStringM = "select * from qryMemorisedknowledge where mid in '%" + txtSearchKnowledge +"%'"

if Request.QueryString("f") = "index" then
txtSearchKnowledge = "index"
'conn.close
'Response.End()
end if


if (Request.Form("Search") = "Search") then
```

```
if txtSearchKnowledge = "" then
Response.Write("Please enter a search string.")
conn.close
Response.End()
end if
end if

%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:800px;dialogHeight:400px;");
}
 function OnSubmitForm()
{

//alert (document.pressed);
  if(document.pressed == 'Search')
  {
   document.forms[0].action ="searchKnowledge.asp";
  }
  else
  if(document.pressed == 'Filter')
  {
    document.forms[0].action ="FilteredKnowledge.asp";
  }
  return true;
}

function submitForm(){
document.forms[0].submit();
}
</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName"> <strong>Consolidated Knowledge</strong>  </div>
  <div align = "left">
    <div id="content1">
      <div class="feature">
        <form method = "post" action= "mKnowledge.asp" >
        <div align="justify"> </div>

        <%
        'onSubmit="return OnSubmitForm();"
'response.Write(sqlString)
'response.End()
response.write("<table width=100%  border=0>")
'rsMKnowledge.open sqlStringM,conn

rsKnowledge.open sqlString,conn

if not (rsKnowledge.eof or rsKnowledge.bof) then
            response.Write("<tr>")
            response.Write("<td> <b>Consolidated knowledge results...</b></td>")
            response.Write("<td>")

while not rsKnowledge.EOF
            response.Write("<tr>")
```

```
            response.Write("<td align=right>Memorise this..<input name=""knowledge"" type=
                checkbox value=""")
            response.write(rsKnowledge.fields(0))
            response.Write(""></td>")
            response.Write("<td>")
            response.Write(rsKnowledge.fields(2))
            response.Write("</td>")
            response.Write("<td>")
            response.Write(rsKnowledge.fields(1))
            response.Write("</td>")
            response.Write("</tr>")

rsKnowledge.movenext
wend
else
response.Write("<b>Please select knowledges to consolidate. Please try again.</b> <a href=#
    onClick=javascript:history.go(-1)> Go Back </a>")
end if
%>

<tr>
<td colspan="3" align="center">
<br><br><br><br>
<input type="submit" name="Filter" value="Memorise Knowledge">
</td>
</tr>
        </table>
        </form>
    </div>
    </div>
  </div>
  <div id="siteInfo">
    <div align="center"><a href="" onClick="javascript:self.close(); return false;">Close</a
        > <a href="index.asp">Cancel </a></div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<%
dim connectionString , conn, filePath
dim category, rsDetails
filePath = server.MapPath("ekp.mdb")
connectionString = "Provider=Microsoft.Jet.OLEDB.4.0;User Id=Admin;Password=;Data Source="+
    filePath+";Persist Security Info=False"
set conn = Server.CreateObject("ADODB.Connection")
set rsDetails = Server.CreateObject("ADODB.Recordset")
conn.connectionstring = connectionString
category = request.Form("eCategory")
conn.open

if (category = "" ) then
category = "Select a category"
category = request.Form("category")
if(category="") then
category = request.QueryString("category")
end if


end if

if (category = "" ) then
    rsDetails.open "select * from knowledgeDetails order by 3,1",conn
else
    rsDetails.open "select * from knowledgeDetails where category =  '"+ category +"'order by
        3,1",conn
end if

if (request.querystring("op") = "delete")then
'   response.Write("delete from knowledgedetails where id = '"+request.querystring("id") +"'")
    category = category
    conn.execute "delete from knowledgedetails where id = "+request.querystring("id")
    rsDetails.requery
end if


%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:1000px;dialogHeight:750px;");
}

function go(){
//document.forms[0].category.value = document.forms[0].eCategory.value;
//alert (document.forms[0].eCategory.value);
document.forms[0].submit();
}
</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 align="center" id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName">
    <div align="center"><strong>Knowledge Management</strong></div>
  </div>
  <div align = "center">
    <div id="content1">
      <div class="feature">
```

```
        <div align="justify">
          <form name="form1" method="post" action="knowledgeManagement.asp">
            <table width="100%"  border="0" cellpadding="0" cellspacing="0">
              <tr>
                <td><div align="right">Existing Category </div></td>
                <td>
                <select name="eCategory" onChange="go();">
                <option value="Select Category">Select Category</option>
                <%
                dim sql,rs
                set rs = Server.CreateObject("ADODB.Recordset")
                sql = "select distinct category from knowledgeDetails order by 1"
                rs.open sql,conn
                while not rs.eof
                %>
                  <option value="<% response.write(rs.fields(0))%>" <% if(rs.fields(0) =
                    category) then response.Write("selected") end if%>><% response.write(rs.
                    fields(0))%> </option>
                <%
                rs.movenext
                wend
                set rs = nothing
                %>
                </select>
                </td>
                <td><a href="knowledgeManagementOP.asp?op=Add&category=<% response.Write
                    (category) %>" title="Add more knowledge">Add</a> </td>
              </tr>
              <tr>
                <td width="19%"><div align="left"><strong>Operation </strong></div></td>
                <td width="19%"><div align="left"><strong>Knowledge Category </strong></div></
                    td>
                <td width="72%"><strong>Knowledge Description </strong></td>
              </tr>
<%
dim bgcolor,prevCat
dim i
i=0
'prevCat = ""
while not rsDetails.eof
i=i+1

if i mod 2 = 0 then
bgcolor = "#FFFFFF"
else
bgcolor = "#9999FF"
'prevCat = rsDetails.fields(2)
end if
%>

              <tr bgcolor=<% response.Write(bgcolor) %>>
<td><a href ="knowledgeManagement.asp?op=delete&id=<%response.Write(rsDetails.fields(0))%>&
    category=<%response.Write(rsDetails.fields(2))%>">Delete</a> |
<a href ="knowledgeManagementOP.asp?id=<% response.Write(rsDetails.fields(0)) %>"> Edit</a>
</td>
                <td><% response.Write(rsDetails.fields(2)) %></td>
                <td><% response.Write(rsDetails.fields(1)) %></td>
              </tr>
<%
rsDetails.movenext
wend
conn.close
set rsDetails = nothing
set conn= nothing
%>
              <tr>
                <td colspan="3"><div align="center">
                  <!--
                  <input type="button" name="Close" value="Close" onClick="javascript:self.
                    close();"> -->
                  <a href="index.asp" title="Cancel"><br>
                  <br>
                  Cancel</a></div></td>
              </tr>
            </table>
          </form>
          <br>
```

```
          </div>
    </div>

    </div>
  </div>
  <div id="siteInfo">
    <div align="center"></div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<%
dim action, filePath
dim connectionString , conn
dim category, knowledgeText, rsD, op
filePath = server.MapPath("ekp.mdb")
connectionString = "Provider=Microsoft.Jet.OLEDB.4.0;User Id=Admin;Password=;Data Source="+
    filePath+";Persist Security Info=False"
'response.Write(connectionString)
'response.End()
set conn = Server.CreateObject("ADODB.Connection")
set rsD = Server.CreateObject("ADODB.Recordset")
action = Request.QueryString("op")
conn.connectionstring = connectionString
conn.open
If (request.QueryString("id") <> "") then
op = "edit"
dim sqlString, category1, knowledgeText1
'conn.open
sqlString = "select * from knowledgeDetails where id =" + request.QueryString("id")
'Response.Write(sqlString)
rsD.open sqlString, conn
category1 = rsD.fields(2)
knowledgeText = rsD.fields(1)
'conn.close
else
op = "new"
end if

if (request.QueryString("op") = "Add") then
category1 = request.QueryString("category")
end if


if (action= "edit") then
category = request.form("category")
knowledgeText = request.Form("knowledgeText")
kid = request.Form("kid")
'conn.open
sqlString = "update knowledgedetails set knowledge = '" + knowledgeText +"' where id = "+
    request.Form("kid")
'response.Write(sqlString)
conn.execute sqlString
Response.write("<form method=post action=knowledgemanagement.asp>")
Response.Write("<div align=center>")
Response.Write("Knowledge Successfully Saved.")
Response.write("<br>Under Category: ")
Response.Write(category)
Response.write("<input type = hidden name = category value=")
response.write("""")
response.write(category)
response.write("""")
response.write(">")
response.Write("<br>")
response.Write("<input type=submit name=""Close"" value=Return>")
Response.Write("</div>")
Response.write("</form>")
conn.close
Response.End()

end if

if (action = "new") then

category = request.Form("category")
knowledgeText = request.Form("knowledgeText")



'conn.execute "INSERT INTO knowledgeDetails ( knowledge, category ) VALUES ('" + knowledgeText
    +"','" + Category +"')"
conn.insertKnowledge knowledgeText,category
Response.write("<form method=post action=knowledgemanagement.asp>")
Response.Write("<div align=center>")
Response.Write("Knowledge Successfully Saved.")
Response.write("<br>Under Category: ")
Response.Write(category)
Response.write("<input type = hidden name = category value=")
```

```
response.write("""")
response.write(category)
response.write("""")
response.write(">")
response.Write("<br>")
response.Write("<input type=submit name=""Close"" value=Return>")
Response.Write("</div>")
Response.write("</form>")
conn.close
Response.End()
end if
%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:1000px;dialogHeight:750px;");
}

function go(){
document.forms[0].category.value = document.forms[0].eCategory.value;
}
</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 align="center" id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName">
    <div align="center"><strong>Knowledge Management</strong></div>
  </div>
  <div align = "center">
    <div id="content1">
      <div class="feature">
        <div align="justify">
          <form name="form1" method="post" action="knowledgeManagementOP.asp?op=<%response.
            Write(op)%>&tb=knowledge">
            <table width="100%"  border="0">
              <tr>
                <td><div align="right">Existing Category </div></td>
                <td>
                <select name="eCategory" onChange="go();" onFocus="go();">
                <%
                'conn.open
                dim sql,rs
                set rs = Server.CreateObject("ADODB.Recordset")
                sql = "select distinct category from knowledgeDetails order by 1"
                rs.open sql,conn
                while not rs.eof
                %>

                  <option value="<% response.write(rs.fields(0))%>"><% response.write(rs.
                    fields(0))%></option>

                <%
                rs.movenext
                wend
                set rs = nothing
                conn.close
                set conn = nothing
                %>
                </select>
```

```
                <input type="hidden" name="kid" value ="<% response.write(request.QueryString
                    ("id"))%>">

</td>
              </tr>
              <tr>
                <td width="19%"><div align="right">Knowledge Category </div></td>
                <td width="81%"><input type="text" name="category" value="<% response.Write
                    (category1)%>"></td>
              </tr>
              <tr>
                <td><div align="right">Knowledge Text </div></td>
                <td><textarea name="knowledgeText" cols="70" rows="8"><% response.Write
                    (knowledgeText)%></textarea></td>
              </tr>
              <tr>
                <td colspan="2"><div align="center">  <input type="submit" name="Save" value
                    ="Save">

                <input type="button" name="Close" value="Close" onClick="javascript:self.close
                    ();">
                <input type="button" name="cancel" value="Cancel" onClick="javascript:history.
                    go(-1);">
                </div></td>
              </tr>
            </table>
          </form>
          <br>
          </div>
    </div>

    </div>
  </div>
  <div id="siteInfo">
    <div align="center"></div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<%
dim connectionString , conn, filePath
dim category, rsDetails
filePath = server.MapPath("ekp.mdb")
connectionString = "Provider=Microsoft.Jet.OLEDB.4.0;User Id=Admin;Password=;Data Source="+
    filePath+";Persist Security Info=False"
set conn = Server.CreateObject("ADODB.Connection")
set rsDetails = Server.CreateObject("ADODB.Recordset")
conn.connectionstring = connectionString
category = request.Form("eCategory")
conn.open

if (category = "" ) then
category = "Select a category"
category = request.Form("category")
if(category="") then
category = request.QueryString("category")
end if


end if

if (category = "" ) then
    rsDetails.open "select * from qryMemorisedknowledge order by 3,1",conn
else
    rsDetails.open "select * from qryMemorisedknowledge where category =  '"+ category
        +"'order by 3,1",conn
end if

if (request.querystring("op") = "delete")then
'   response.Write("delete from knowledgedetails where id = '"+request.querystring("id") +"'")
    category = category
    conn.execute "delete from memorisedknowledge where mid = "+request.querystring("id")
    rsDetails.requery
end if


%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:1000px;dialogHeight:750px;");
}

function go(){
//document.forms[0].category.value = document.forms[0].eCategory.value;
//alert (document.forms[0].eCategory.value);
document.forms[0].submit();
}
</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 align="center" id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName">
    <div align="center"><strong>Knowledge Management</strong></div>
  </div>
  <div align = "center">
    <div id="content1">
      <div class="feature">
```

```
        <div align="justify">
          <form name="form1" method="post" action="memorisedknowledgeManagement.asp">
            <table width="100%"  border="0" cellpadding="0" cellspacing="0">
              <tr>
                <td><div align="right">Existing Category </div></td>
                <td>
                <select name="eCategory" onChange="go();">
                <option value="Select Category">Select Category</option>
                <%
                dim sql,rs
                set rs = Server.CreateObject("ADODB.Recordset")
                sql = "select distinct category from knowledgeDetails order by 1"
                rs.open sql,conn
                while not rs.eof
                %>
                  <option value="<% response.write(rs.fields(0))%>" <% if(rs.fields(0) =
                    category) then response.Write("selected") end if%>><% response.write(rs.
                    fields(0))%> </option>
                <%
                rs.movenext
                wend
                set rs = nothing
                %>
                </select>
                </td>
                <td><!--<a href="knowledgeManagementOP.asp?op=Add&category=<%' response.Write
                    (category) %>" title="Add more knowledge">Add</a> --></td>
              </tr>
              <tr>
                <td width="19%"><div align="left"><strong>Operation </strong></div></td>
                <td width="19%"><div align="left"><strong>Knowledge Category </strong></div></
                    td>
                <td width="72%"><strong>Knowledge Description </strong></td>
              </tr>
<%
dim bgcolor,prevCat
dim i
i=0
'prevCat = ""
while not rsDetails.eof
i=i+1

if i mod 2 = 0 then
bgcolor = "#FFFFFF"
else
bgcolor = "#9999FF"
'prevCat = rsDetails.fields(2)
end if
%>

              <tr bgcolor=<% response.Write(bgcolor) %>>
<td><a href ="memorisedknowledgeManagement.asp?op=delete&id=<%response.Write(rsDetails.fields
    (3))%>&category=<%response.Write(rsDetails.fields(2))%>">Delete</a>
</td>
                <td><% response.Write(rsDetails.fields(2)) %></td>
                <td><% response.Write(rsDetails.fields(1)) %></td>
              </tr>
<%
rsDetails.movenext
wend
conn.close
set rsDetails = nothing
set conn= nothing
%>
              <tr>
                <td colspan="3"><div align="center">
                  <!--
                  <input type="button" name="Close" value="Close" onClick="javascript:self.
                    close();"> -->
                  <a href="index.asp" title="Cancel"><br>
                  <br>
                  Cancel</a></div></td>
              </tr>
            </table>
          </form>
          <br>
          </div>
```

```
    </div>

    </div>
  </div>
  <div id="siteInfo">
    <div align="center"></div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<%
dim txtSearchKnowledge1,txtSearchKnowledge, filePath,connectionString,conn,rsKnowledge,
    sqlString,sqlStringM,rsMKnowledge
dim rsSearchM,sqlStringS'txtSearchKnowledge = request.form("txtSearchKnowledge")
filePath = server.MapPath("ekp.mdb")
set conn = Server.CreateObject("ADODB.Connection")
set rsKnowledge = Server.CreateObject("ADODB.Recordset")
set rsSearchM = Server.CreateObject("ADODB.Recordset")
connectionString = "Provider=Microsoft.Jet.OLEDB.4.0;User Id=Admin;Password=;Data Source="+
    filePath+";Persist Security Info=False"
conn.connectionString = connectionString
conn.open
txtSearchKnowledge=""
'isFound = False
'Response.Write(Request.Form("knowledge").Count)
'if (Request.Form("mKnowledge") = "Memorise Knowledge") then
for i=1 to Request.Form("knowledge").Count
    isFound = true
    txtSearchKnowledge = Request.Form("knowledge")(i)
    sqlStringS = "select * from memorisedKnowledge where kid ="+txtSearchKnowledge
    rsSearchM.open sqlStringS,conn
    if rsSearchM.EOF or rsSearchM.BOF then
        sqlString = "Insert into memorisedKnowledge(kid) values("+ txtSearchKnowledge + ")"
        conn.execute sqlString
    end if
    rsSearchM.close
    'response.Write(sqlString)
    txtSearchKnowledge1 = txtSearchKnowledge1 + "," + Request.Form("knowledge")(i)

'   Response.Write(Request.Form("knowledge")(i) & "<br />")
next
if isFound then
txtSearchKnowledge1 = right(txtSearchKnowledge1,len(txtSearchKnowledge1)-1)
end if
'end if
if isFound = false then
txtSearchKnowledge1 = "0"
end if

sqlString = "select * from knowledgeDetails where id in (" + txtSearchKnowledge1 +")"
'response.Write(sqlString)
'response.end
%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:800px;dialogHeight:400px;");
}
 function OnSubmitForm()
{

//alert (document.pressed);
  if(document.pressed == 'Search')
  {
   document.forms[0].action ="searchKnowledge.asp";
  }
  else
  if(document.pressed == 'Filter')
  {
    document.forms[0].action ="FilteredKnowledge.asp";
  }
  return true;
}

function submitForm(){
document.forms[0].submit();
}
</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
```

```
<body>


<div id="masthead" align="center">
  <h1 id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName"> <strong>Memorise these Knowledge</strong>  </div>
  <div align = "left">
    <div id="content1">
      <div class="feature">
        <form method = "post" action= "mKnowledge.asp" >
        <div align="justify"> </div>

        <%
        'onSubmit="return OnSubmitForm();"
'response.Write(sqlString)
'response.End()
response.write("<table width=100%  border=0>")
'rsMKnowledge.open sqlStringM,conn
rsKnowledge.open sqlString,conn
if not (rsKnowledge.eof or rsKnowledge.bof) then
            response.Write("<tr>")
            response.Write("<td> <b>Memorise the knowledges below...</b></td>")
            response.Write("<td>")

while not rsKnowledge.EOF
            response.Write("<tr>")
            response.Write("<td>")
            response.Write(rsKnowledge.fields(2))
            response.Write("</td>")
            response.Write("<td>")
            response.Write(rsKnowledge.fields(1))
            response.Write("</td>")
            response.Write("</tr>")

rsKnowledge.movenext
wend
'else
'response.Write("<b>No matching knowledge found. Please try again.</b>")
end if
%>
<%
if isFound = false then
response.Write("<tr>")
response.write("<td>")
response.Write("<b>The system is unable to memorise knowledge, Please select a knowledge...</b
    > <a href=# onClick=javascript:history.go(-1)> Go Back </a>")
response.Write("</td>")
response.write("</tr>")

end if

%>
<tr>
<td colspan="3" align="center">
<br><br><br><br>
<%
if isFound = false then
response.write("<input type=submit name=mKnowledge value=Memorise Knowledge>")
end if

%>
</td>
</tr>
        </table>
        </form>
    </div>
    </div>
  </div>
  <div id="siteInfo">
    <div align="center"><a href="" onClick="javascript:self.close(); return false;">Close</a
```

```
        > <a href="index.asp">Cancel </a></div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```

```
<%
dim txtSearchKnowledge, filePath,connectionString,conn,rsKnowledge,sqlString,sqlStringM,
    rsMKnowledge
txtSearchKnowledge = request.form("txtSearchKnowledge")
filePath = server.MapPath("ekp.mdb")
set conn = Server.CreateObject("ADODB.Connection")
set rsKnowledge = Server.CreateObject("ADODB.Recordset")
set rsMKnowledge = server.CreateObject("ADODB.Recordset")
connectionString = "Provider=Microsoft.Jet.OLEDB.4.0;User Id=Admin;Password=;Data Source="+
    filePath+";Persist Security Info=False"

conn.connectionString = connectionString

conn.open
if request.QueryString("f") = "index" then
txtSearchKnowledge = "index"
'conn.close
'Response.End()
end if


if (Request.Form("Search") = "Search") then
if txtSearchKnowledge = "" then
Response.Write("Please enter a search string.")
conn.close
Response.End()
end if
end if

%>
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html14/loose.dtd">
<html>
<!-- DW6 -->
<head>
<script language="jscript">
function modalwin(pagename) {
window.showModalDialog(pagename,"popup","dialogWidth:800px;dialogHeight:400px;");
}
 function OnSubmitForm()
{

//alert (document.pressed);
  if(document.pressed == 'Search')
  {
   document.forms[0].action ="searchKnowledge.asp";
  }
  else
  if(document.pressed == 'Consolidate Knowledge')
  {
    document.forms[0].action ="FilteredKnowledge.asp";
  }
  return true;
}

function submitForm(){
document.forms[0].submit();
}
</script>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1">
<META HTTP-EQUIV="Pragma" CONTENT="no-cache">
<title>Evolving Knowledge Process (EKP)</title>
<link rel="stylesheet" href="emx_nav_left.css" type="text/css">
</head>
<body>


<div id="masthead" align="center">
  <h1 id="siteName">Evolving Knowledge Process (EKP) </h1>

</div>
<!-- end masthead -->
<div id="pagecell1">
  <!--pagecell1-->
  <img alt="" src="tl_curve_white.gif" height="6" width="6" id="tl"> <img alt="" src
    ="tr_curve_white.gif" height="6" width="6" id="tr">
  <div id="pageName"> <strong>Search and Consolidate Knowledge</strong>  </div>
```

```
  <div align = "left">
    <div id="content1">
      <div class="feature">
        <form method = "post" action= "searchKnowledge.asp" onSubmit="return OnSubmitForm();">
        <div align="justify"> Search Knowledge:
          <input type="text" name="txtSearchKnowledge" size="40">
          <input type="submit" name="Search" value="Search" onClick = "document.pressed=this.
            value">
        </div>

<%
sqlString = "select * from knowledgeDetails where knowledge like '%" + txtSearchKnowledge
    +"%' or category  like '%" + txtSearchKnowledge + "%'"
sqlStringM = "select * from qryMemorisedknowledge where knowledge like '%" +
    txtSearchKnowledge +"%' or category  like '%" + txtSearchKnowledge + "%'"
'response.Write(sqlString)
response.write("<table width=100%  border=0>")
rsMKnowledge.open sqlStringM,conn
rsKnowledge.open sqlString,conn
if not (rsKnowledge.eof or rsKnowledge.bof) then
            response.Write("<tr>")
            response.Write("<td> <b>Existing knowledge results...</b></td>")
            response.Write("<td>")

while not rsKnowledge.EOF
            response.Write("<tr>")
            response.Write("<td align=right>Filter and Consolidate this..<input name
                =""knowledge""")
'           response.Write(rsKnowledge.fields(0))
            response.Write(" type=checkbox value=""")
            response.write(rsKnowledge.fields(0))
            response.Write(""">")
            'response.write("<input name = category type=hidden value=""")
            'response.write(rsKnowledge.fields(2))
            'response.Write(""">")
            response.write ("</td>")
            response.Write("<td>")
            response.Write(rsKnowledge.fields(2))
            response.Write("</td>")
            response.Write("<td>")
            response.Write(rsKnowledge.fields(1))
            response.Write("</td>")
            response.Write("</tr>")

rsKnowledge.movenext
wend
else
response.Write("<b>No matching knowledge found. Please try again.</b>")
end if

if not (rsMKNowledge.bof or rsMKnowledge.eof) then
            response.Write("<tr>")
            response.Write("<td> <b>Existing memorised knowledge ...</b></td>")
            response.Write("<td>")

while not (rsMKnowledge.bof or rsMKnowledge.eof)

            response.Write("<tr>")
            response.Write("<td align=right>Filter this..<input name=""mknowledge"" type=
                checkbox value=")
            response.Write(rsMKnowledge.fields(0))
            response.Write("></td>")
            response.Write("<td>")
            response.Write(rsMKnowledge.fields(2))
            response.Write("</td>")
            response.Write("<td>")
            response.Write(rsMKnowledge.fields(1))
            response.Write("</td>")
            response.Write("</tr>")

rsMKNowledge.movenext
wend

else
            response.Write("<tr")
            response.Write("<td><br><b>No matching memorised knowledge found.</b></td>")
            response.Write("</tr>")
```

```
end if
            response.Write("<br>")
            response.Write("<tr>")
            response.Write("<td> <input type=submit name=Filter value=""Consolidate
                Knowledge"" onClick = document.pressed=this.value> </td>")
'           response.Write("<td align=left> <b><a href =# value = filter onClick = document.
    pressed=this.value> Click to filter knowledge </a></b></td>")
            response.Write("</tr>")


%>

        </table>
        </form>
    </div>

    </div>
  </div>
  <div id="siteInfo">
    <div align="center"><a href="" onClick="javascript:self.close(); return false;">Close</a
        > <a href="index.asp">Cancel </a></div>
  </div>
</div>
<!--end pagecell1-->
<br>
</body>
</html>
```