Process Model for Knowledge Management

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Chapter 1: Introduction

Overview

The 1990s have seen the emergence of global software development centers or Global Development Centers (GDCs) located in different parts of the world to serve the software development needs of companies. A GDC forms a large-scale, economic model for the remote development of software driven by cost benefits offered by the workforce in these locations. A GDC organization performs a large number of somewhat similar projects for one or more customers over a long period of time, often ten to fifteen years. This offers an opportunity to derive economic benefits by understanding and building on past, similar work performed by the GDC for a customer and reusing the solutions for future work.

This document provides an overview of different process models used in knowledge management. The document goes on to propose a process model based on the core principles of the Capability Maturity Model which is part of a structured knowledge management framework. Core elements of the model were used to create the specifications for a prototype tool. Components of the structured framework include a formal specification, supported by multiple perspectives or classification schemes and a prototype tool that has been developed for usage in this context.

Models in Knowledge Management

This section provides information on different models used for knowledge management. First, general models for knowledge management are outlined. Next, knowledge management models that are based on maturity models are described with examples of such models.

General Models

There have been several efforts at developing frameworks and models to reflect an understanding of knowledge management. These can be broadly classified into two categories: descriptive and prescriptive. The descriptive models attempt to characterize the nature of KM phenomena, whereas prescriptive ones prescribe methodologies to follow in conducting knowledge management (Holsapple and Joshi: 1999). The result of this is the appearance of several theoretical models that attempt to explain how organizational knowledge is created, transferred and crystallized (Laverde et al: 2003). In a study of over 160 frameworks, the KM activities can be described with the five central activities of sharing, creating, using, storing and identifying (Heisig: 2009). The essence of a set of models used for describing knowledge management has been defined in Table 1.1.

Table 1.1: Knowledge Management Models

Framework	Description
Knowledge Management Pillars (Wiig: 1993)	This defines three KM pillars in the model as shown in Figure 1.1. The first pillar is concerned with exploring knowledge and its adequacy. The second pillar involves appraising and evaluating the value of knowledge and knowledge-related activities. The third pillar focuses on governing knowledge management activity.
Knowledge Conversion (Nonaka: 1994)	This model identifies four kinds of knowledge conversion that drive knowledge creation: socialization, externalization, internalization, and combination as shown in Figure 1.2. Organizational knowledge is created by the interactions among these four conversion processes, and through transfer of tacit/explicit knowledge from individual to group to organizational levels.
Knowledge Building (Leonard-Barton: 1995)	The model has four core capabilities and four knowledge building activities as shown in Figure 1.3. Knowledge building includes shared and creative problem solving, implementing and integrating new methodologies and tools, experimenting and prototyping, and importing and absorbing technologies from outside of the firm's knowledge. These are knowledge creating and diffusing activities. The four core capabilities identified in this framework are physical systems, employee knowledge and skills, managerial system routines directing resource accumulation and deployment creating the channels through which knowledge is accessed and flows and the organization's values and norms.
Knowledge Transfer (Szulanski: 1996)	This model analyzes internal stickiness of knowledge transfer, with a focus on transfer of best practices. Internal stickiness refers to the difficulty of transferring knowledge within an organization. The framework identifies four stages involved in knowledge transfer: initiation, implementation, ramp-up, and integration. It identifies four factors that impact the difficulty of knowledge transfer: nature of knowledge transfer (causal ambiguity), nature of source of knowledge (lack of motivation and perceived unreliability), nature of recipient (lack of motivation, lack of absorptive capacity, and lack of retentive capacity), and nature of the context (barren organizational context and arduous relationship).
Tannenbaum and Alliger's Model, (Tannenbaum and Alliger: 2000)	The model provides a systematic approach to determine the effectiveness of Knowledge Management by examining four aspects: knowledge sharing, knowledge accessibility, knowledge assimilation and knowledge application.
Rastogi's Model, Rastogi: 2000	The knowledge model includes identification of knowledge, mapping including expertise and skills, knowledge capture, knowledge and know-hoe acquisition, knowledge storage, knowledge sharing, and knowledge-centric decision-making. The most advanced step is creating generating or discovering new knowledge through experimentation, lessons learned, creative thinking and innovation.
Building blocks of knowledge management, (Probst et al: 2002)	This model involves eight components that form two cycles, one inner cycle and other outer cycle. The inner cycle is composed by the building blocks of identification, acquisition, development, distribution, utilization and preservation of knowledge. There are two other processes in the outer cycle, knowledge goals and assessment, which provide the direction to the Knowledge Management cycle.
Unified Knowledge Management, (Heisig: 2009)	This model is composed of four processes: Create which refers to the ability to learn and communicate, Store which requires a structured storage capability, Distribute which refers to the development of a team spirit that supports the sharing of knowledge, Apply which suggests that it is possible to create more knowledge with the concrete application of new knowledge.
Knowledge Management Cycle (McElroy: 2002)	McElroy model divides the Knowledge Creation Process in two big processes, Knowledge Production and Knowledge Integration. Knowledge Production is the process were new organizational knowledge is created and is synonymous to organizational learning. Knowledge Integration is formed by some activities that

allow the knowledge sharing and distribution. The model introduces two concepts named Supply Side and Demand Side. Supply Side includes practices that are designed to enhance the supply of existing knowledge to workers in an enterprise. Demand Side focuses on enhancing an organization's capacity to satisfy its demand for new knowledge.

Knowledge Management

I		II		III
Survey & Categorize Knowledge		Appraise & Evaluate Value of Knowledge		Synthesize Knowledge Related Activities
Analyze Knowledge & Related Activities		&		Handle, Use, & Control Knowledge
Elicit, Codify, & Organize Knowledge		Knowledge Related Actions		Leverage, Distribute, & Automate Knowledge

Knowledge Management Foundation

Broad Understanding of Knowledge

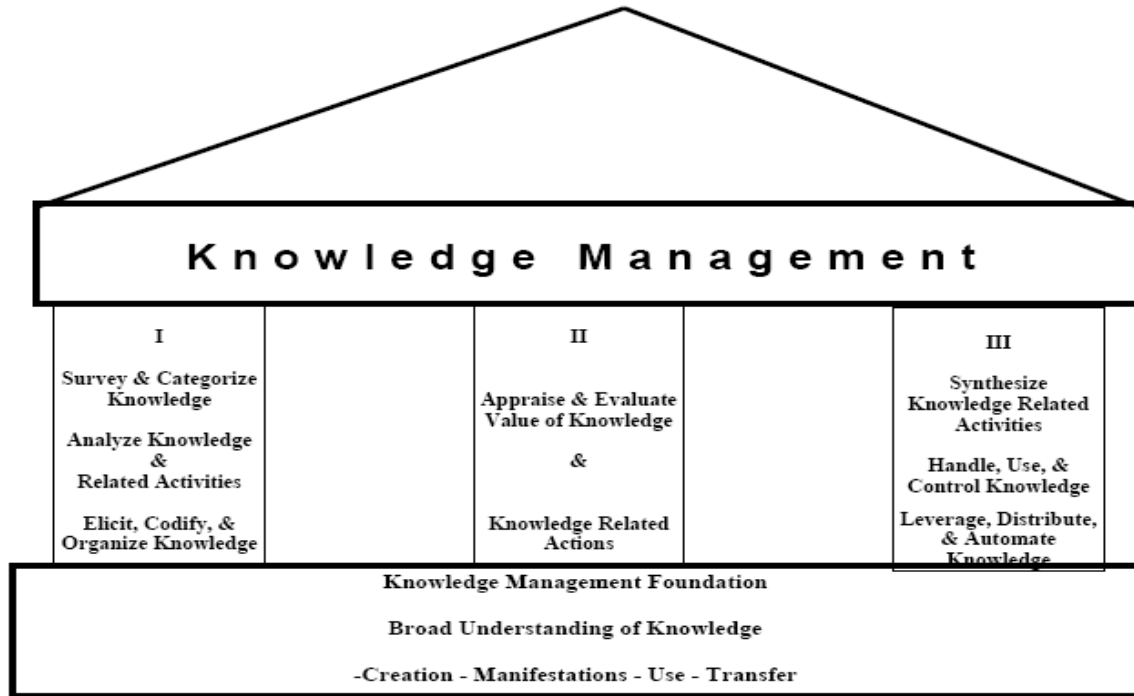-Creation - Manifestations - Use - Transfer
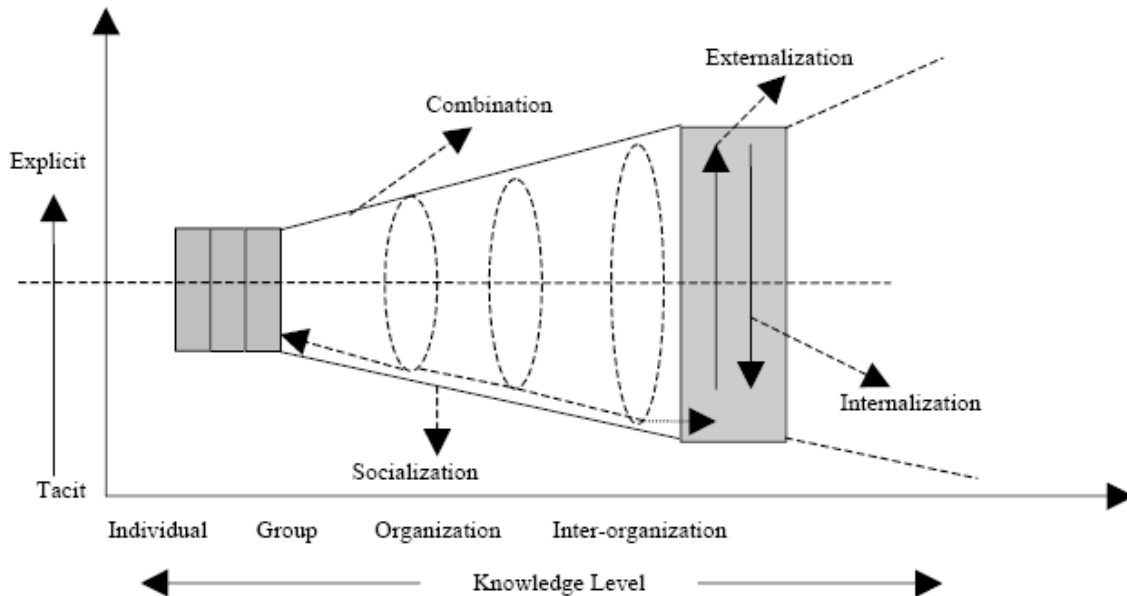
Figure 1.1: Wiig's Pillars

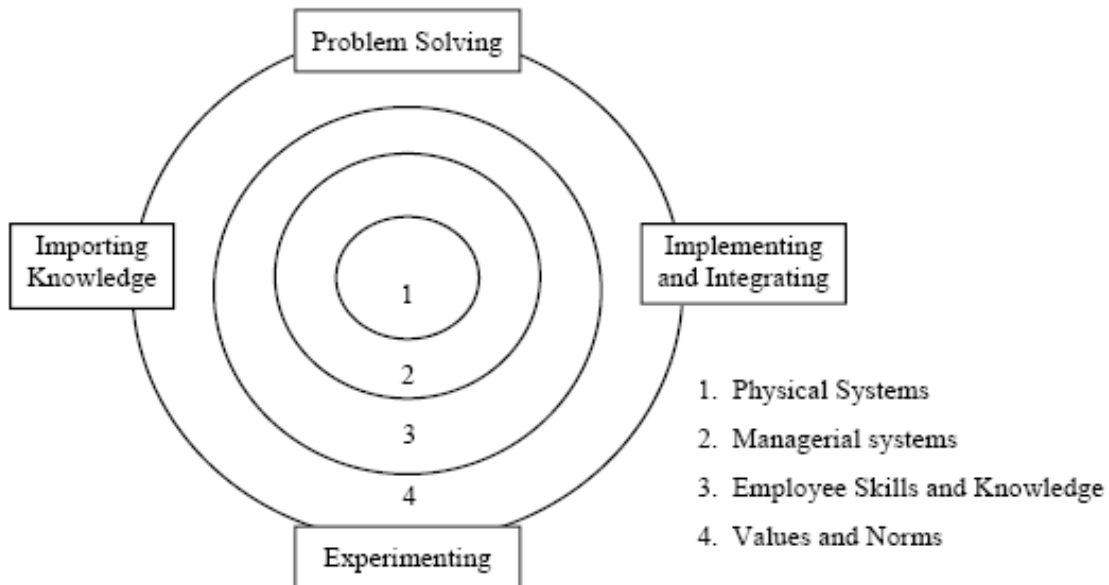**Figure 1.2: Nonaka's Knowledge Conversion**

Figure 1.3: Leonard-Barton's Knowledge Building Model

These approaches have some limitations. Knowledge management activities are only analyzed from the view of knowledge lifecycle and focused on the design of knowledge systems. Alternately, a model can be created to integrate with the business process. This model has been described where the business process is product development process (Deng and Yu: 2006). The two parts are interlinked. During the product development process, employees seek for massive amounts of information and knowledge for application of dealing with the problem-solving tasks, and generate new knowledge. Knowledge management can be used to develop and enhance the product development process on an ongoing basis using the following (Deng and Yu: 2006):

- Analyzing the product development process through process modeling.

- Linking KM strategy with product development domain.

- Structuring knowledge in product development through process model.

- Integrating KM process into the product development process.

- Integrating KM system into product development.

In a GDC setup, the above model works well, since it offers a meaningful integration between the business of developing software and the knowledge management practices adopted by the organization – it is very important for meaningful linkages between the two, driven by the economic needs of the business of software development.

Maturity Models

Maturity Models describe the development of entities over time, with the entity being anything of interest. Each entity develops through the levels over time until it reaches the highest, optimized, level. Maturity models have the following properties (Klimko 2000, Weerdmeester et al. 2003):

- The development of a single entity is simplified and described with a limited number of maturity levels (usually four to six).

- Levels are characterized by certain requirements, which the entity has to achieve on that level.

- Levels are ordered sequentially, from an initial level up to an ending level (the latter is the level of perfection).

- During development, the entity progresses forward from one level to the next. No levels can be skipped (Pee et al: 2006).

Knowledge management maturity has been a major topic of research in recent years (Kochikar 2000, Ehms and Langen 2002, KPMG 2003, Pee et al: 2006). While many knowledge management maturity models have been proposed, details on how an entity's maturity can be assessed remains elusive (Pee et al: 2006). Researchers and practitioners have proposed maturity modeling as a way as a way of formally capturing the KM development process by assessing the extent to which KM is explicitly defined, managed, controlled, and effective (Kochikar: 2000, Kulkarni and Freeze: 2004, Kulkarni and St. Louis: 2003, Paulzen and Perc: 2002).

Maturity Models based on CMM

The Capability Maturity Model. The Capability Maturity Model for Software (CMM) is a framework that describes the key elements of an effective software process. The CMM describes an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process. The CMM covers practices for planning, engineering, and managing software development and maintenance. When followed, these key practices improve the ability of organizations to meet goals for cost, schedule, functionality, and product quality (Paulk et al: 1993). CMM was inspired from principles of Total Quality Management (Crosby: 1979), and the general improvement idea was built into the model from work done in improvement in organizations (Juran and Gryna 1988, Deming 1982). The CMM arises because software development is a tumultuous human process. It entails fast-moving computer technology. It entails teams of highly skilled, extremely mobile professional workers who must apply creativity and innovation in their development. This chaotic setting prevents software development organizations from delivering their products on time and within budget, if the products are successfully delivered at all (Baskerville and Pries-Heje: 1999). This maturity framework should be applied only to practices that contribute directly to the business performance of an organization. These are the practices that increase the organization's capability to provide high-quality

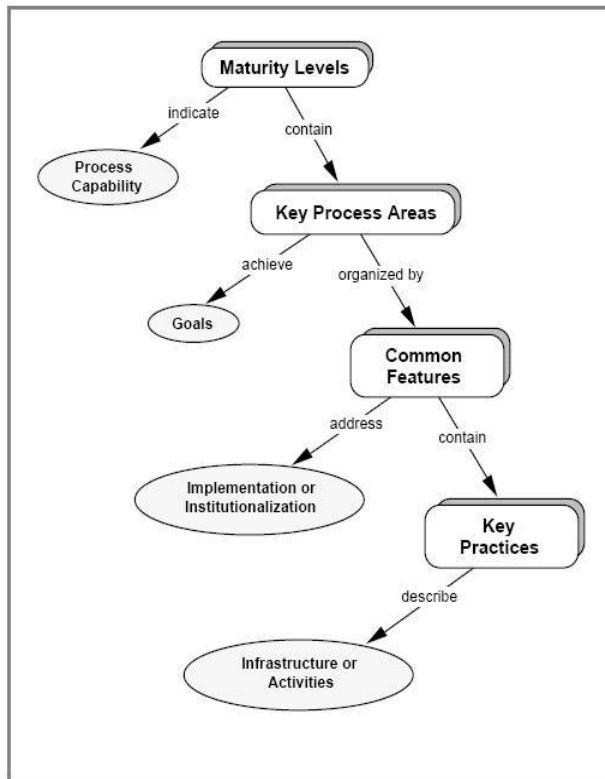products and services efficiently. The structure of CMM is depicted in Figure 1.4 (Paulk et al: 1993).

Figure 1.4: Structure of Capability Maturity Model (Paulk et al: 1993)

In an organization's least mature state represented by the Initial level, systematic and repeated performance of practices is sporadic. The Repeatable level of the CMM is primarily focused on helping software organizations repeat successful software development or maintenance practices. The primary objective at the Repeatable level is to ensure that the basic practices are performed on a regular and repeatable basis. Capitalizing on processes that work best is the heart of the Defined level. The objective of the Managed level is to set quantitative performance and quality targets and reduce the variation in process to stabilize the organization's capability in achieving these targets. At the Optimizing level, the organization continues on its improvement path with a focus on continuous process improvement. Figure 1.5 shows the different levels of software maturity (Paulk et al: 1993).
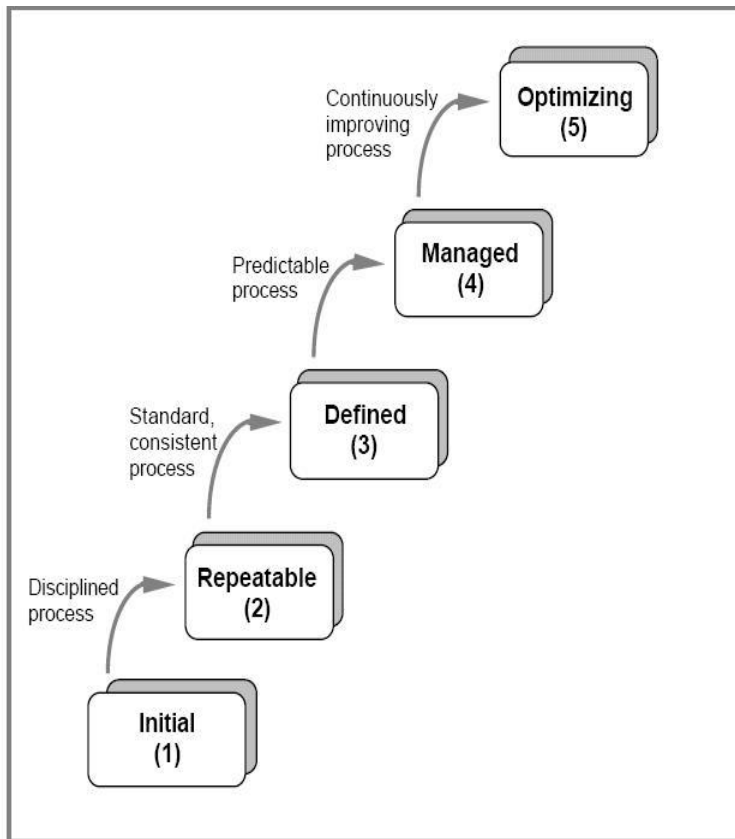
Figure 1.5: Levels of Software Maturity (Paulk et al: 1993)

The CMM framework builds an environment in which practices can be repeated best practices can be rapidly transferred across groups, variations in performing best practices are reduced, and practices are continuously improved to enhance capability.   These are the practices that increase the organization's capability to provide high-quality products and services efficiently.

Siemens KMMM Model. The Siemens KMMM consists of an analysis and development model (Figure 1.5) and a defined assessment model (Figure 1.6). The analysis model takes account of important aspects of knowledge management and reveals areas that should be developed in future. The development model provides information as to how the respective key areas and topics can be best developed to reach the next maturity level. The assessment process structures all relevant steps from assessment definition to result interpretation (Ehms and Langen: 2002).
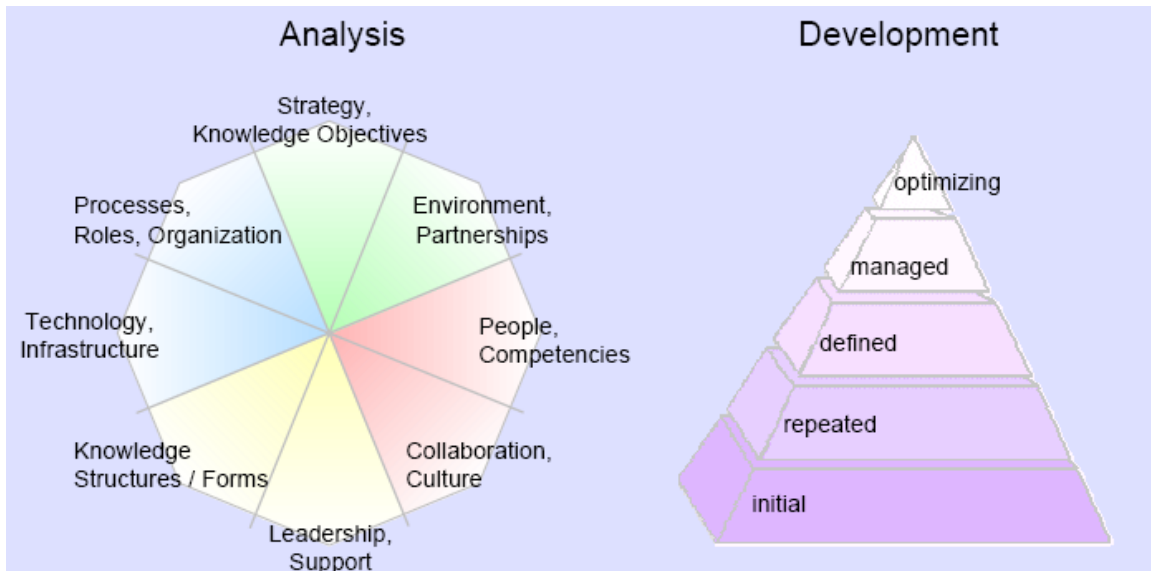
Figure 1.6: Analysis and Development Model
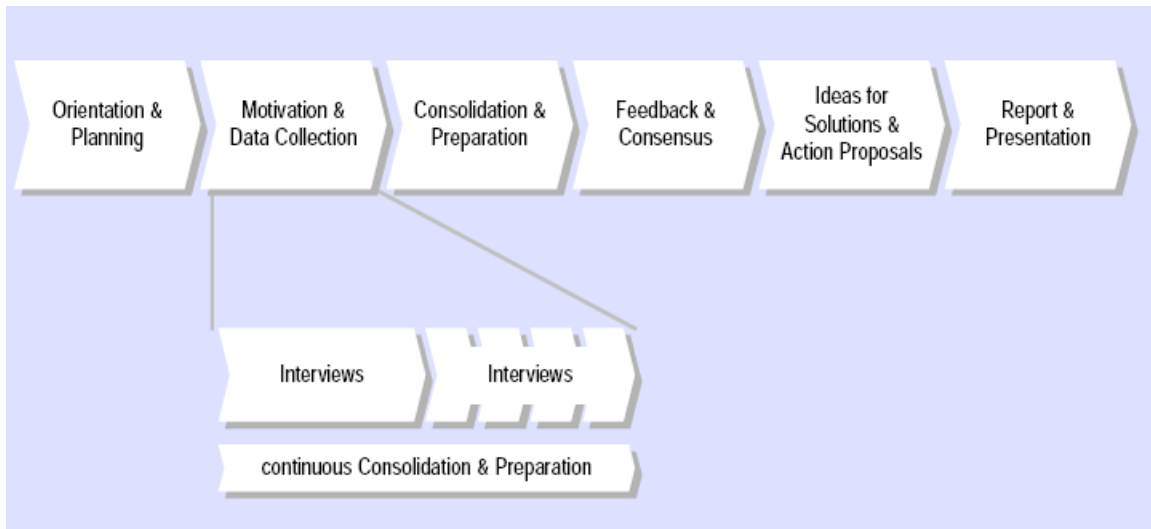
Figure 1.7: Assessment Model

The analysis areas are measured along four perspectives – time horizon, knowledge, actor and rules to define eight key process areas represented as a spatial arrangement as shown in Figure 1.6. These are drilled down to 64 knowledge management topics that form the basis for mapping the organization's knowledge capability assessment onto the spatial map. This model does not have a specific reference to software development organizations that develop software in the context of projects.

Mitre KM-CMM. Mitre has designed a maturity model of knowledge management modeled summarized in Figure 1.7. The KM-CMM is organized into five maturity levels.

The KM-CMM can be used for organizational assessment, gap analysis, and prioritization of KM investments and improvement initiatives (Maybury: 2003). Mitre's approach includes processes and technologies that enable the enterprise to acquire, create, share, and make actionable knowledge needed to achieve corporate objectives. Core knowledge management processes such as the creation, sharing and application of knowledge are performed within a context of the influence of corporate processes, practices and culture. They are supported by a number of enabling technologies such as intranets, information push/pull, data mining, expert finding, expert practice databases, knowledge mapping, and so on (Maybury: 2003). The model is a general purpose one that can be mapped on to any organization.
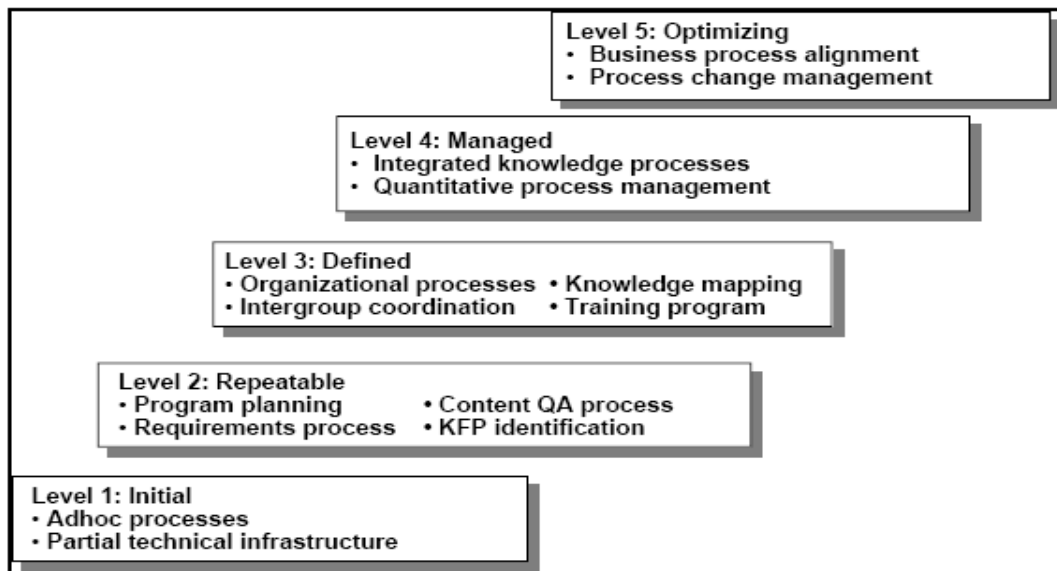

Level 5: Optimizing
• Business process alignment
• Process change management

Level 4: Managed
• Integrated knowledge processes
• Quantitative process management

Level 3: Defined
• Organizational processes   • Knowledge mapping
• Intergroup coordination   • Training program

Level 2: Repeatable
• Program planning   • Content QA process
• Requirements process   • KFP identification

Level 1: Initial
• Adhoc processes
• Partial technical infrastructure

Figure 1.8: Mitre KM-CMM Model

KPQM (Knowledge Process Quality Model). The KPQM model (Paulzen and Perc: 2002) developed a maturity model defined using a maturity model dimension, a knowledge area dimension, a management area dimension and an assessment structure. Knowledge activities represent those portions of the business activities that focus in the area of knowledge. Management areas are associated with people, organization and technology. The assessment structure consists of process attributes mapped on to each maturity level and aligned to each management area.

Infosys KMM. The Infosys model for knowledge management focuses on sharing knowledge and uses this as the basis to define the maturity along five levels of maturity. The key process areas are defined along the lines of people, process and technology. The Infosys model is shown in Figure 1.8, and consists of the following (Kochikar: 2001)

- Content architecture: to manage content, audience, and access level. Both internal and external content are submitted for review and the repository is updated.

- Technology architecture: to manage different technologies including a repository and a portal for intranet and extranet users.

- People architecture: The people architecture includes a central knowledge management group, practice champions, and reviewers.

- Process architecture: Processes are defined to facilitate knowledge sharing and reuse, ensure content quality and currency, and define effectiveness and benefits measures.

Content Architecture
- Internal, External
- Knowledge-node hierarchy

Technology Architecture
- Knowledge Shop - the Knowledge Portal

People Architecture
- Facilitated Decentralized Approach
- Knowledge Currency Units(KCUs)

Process Architecture
- Facilitation process
- Content Management Process
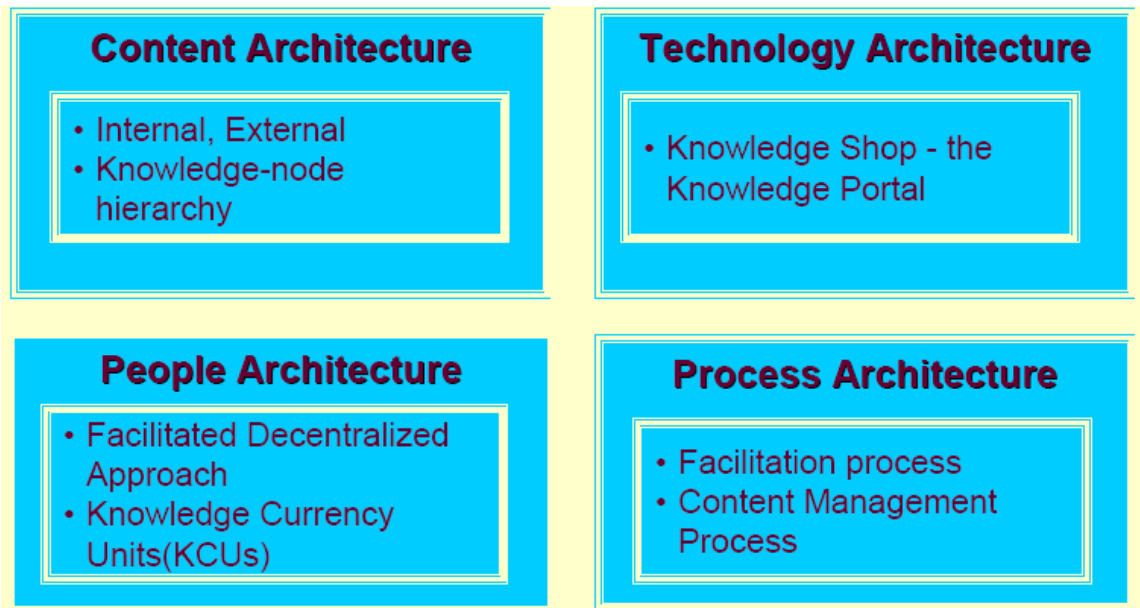
Figure 1.9: Infosys KMM

KMMM Pyramid Model. The KMMM Pyramid Model (Hung and Chow: 2005) has three components model, namely, maturity levels, knowledge management processes, and knowledge management capabilities or enabling infrastructures, representing a three dimensional model as defined in Figure 3.9. The capability perspective defines technical, structural, and cultural perspectives. The structural infrastructure makes reference to the presence of norms and trust mechanisms. The cultural dimension is built upon a sharing context. The technological dimension addresses the technology-enabled infrastructures that exist within the firm (Hung and Chow: 2005). This is a general-purpose model and interviewing was conducted with companies belonging to the banking segment to determine the efficacy of the model.

Figure 1.10: The KMMM Pyramid Model (Hung and Chow: 2005)
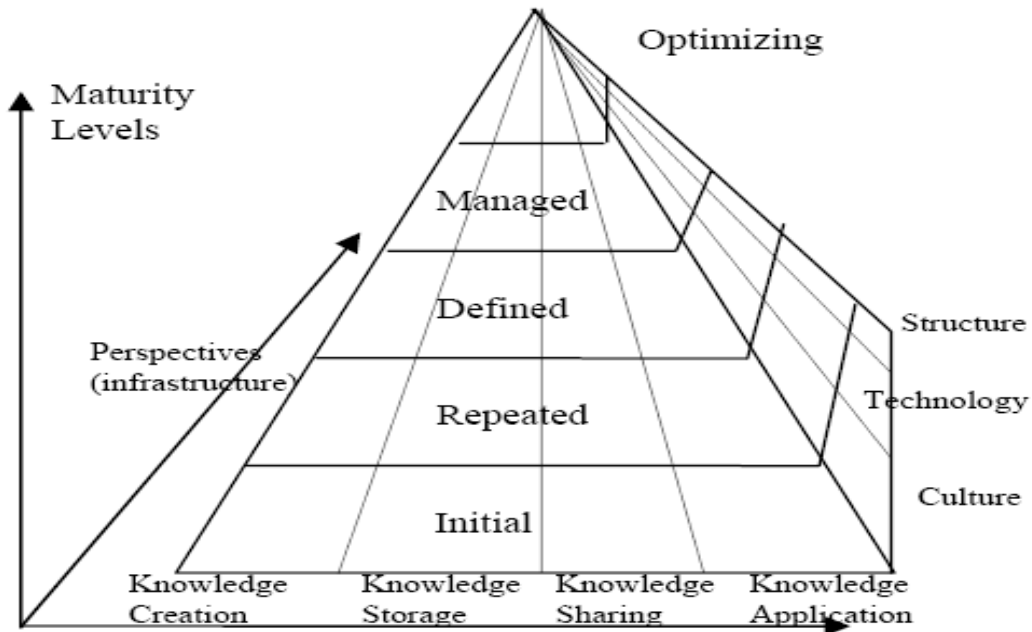
Table 1.2 summarized key aspects of the maturity models.

Table 1.2: CMM Based Maturity Models

Framework	Description
Mitre Model	Initial: The knowledge process is ad hoc and chaotic. Partial (if any) technical infrastructure exists to support knowledge discovery and sharing.
	Repeatable: Basic knowledge management program is established to track requirements, content and investments. Process discipline is in place to assure quality of knowledge and/or to repeat earlier knowledge successes and/or knowledge transfer on similar projects ensuring some basic knowledge quality and reuse. A knowledge focal point is identified.
	Defined: At this level, the process for both knowledge management and knowledge engineering activities is documented. Processes are standardized across the organization. Manual or semi-automated methods for mapping knowledge are applied and available across the enterprise. Training and inter-group coordination is used for knowledge discovery and dissemination.
	Managed. At this level, detailed measures of the knowledge process and product quality are collected. Both the knowledge process and products are quantitatively understood and controlled.
	Optimizing. At this level, continuous process improvement is enabled by quantitative feedback from the process and from piloting innovation. Knowledge management activities are closely aligned with business functions.
Siemens Model	Initial: Knowledge processes are not consciously controlled. There is no language in place to describe phenomena or problems from a knowledge perspective.
	Repeatable: Organizations have recognized the importance of knowledge management activities for their business. Organizational processes are partly described as knowledge management tasks. Pilot projects exist. Individual activities can serve as the seeds of further, integrated knowledge management

	activities.
	Defined: There are stable and practiced activities that effectively support the KM of individual parts of the organization. These activities are integrated in the day-to-day work processes and the corresponding technical systems are maintained. Individual KM roles have been defined and filled.
	Managed: A common strategy and standardized approaches to the subject of knowledge management is a feature of the organization. Knowledge activities are regularly measured. There are defined organization-wide roles and compatible socio-technical KM systems.
	Optimizing: Organization has developed the ability to adapt flexibly in order to meet new requirements in knowledge management. These challenges are mastered even in the case of larger external or internal changes.
Infosys KM	Default: Knowledge management processes are not planned formally.
	Reactive: Routine and procedural knowledge is shared. Knowledge shared on a need basis.
	Aware: Initial understandings of metrics in place, managers recognize their role in knowledge sharing.
	Convinced: Enterprise-wide knowledge sharing system in place.
	Sharing: Culture of sharing is institutionalized.
KPQM	Initial: Knowledge management processes are not planned formally, and the state is chaotic.
	Aware: Awareness of knowledge management has been gained.
	Established: Focuses on systematic structure and definition of knowledge processes.
	Quantitatively Managed: Measures of performance is in place.
	Optimizing: Focuses on optimization and continuous improvement.

Non-CMM Based Maturity Models

Non-CMM maturity models are based on the concept that maturity is achieved by following a systematic implementation for knowledge management that do not require an organization to be completely conformant to a maturity level before proceeding to more advanced maturities.

Knowledge Journey. KPMG's Knowledge Journey is a flexible model that supports the consulting efforts that looks at four key process areas, namely people, process, content and technology, with each area having a checklist of items. This is one of the few maturity models that have been empirically tested and applied across 423 organizations worldwide in a KM study (KPMG: 2000). The number and the mix of items applicable to the organization define the maturity of an organization.

VISION KMM. VISION KMMM consists of two different dimensions of maturity: a research, technological development and demonstration (RTD) oriented maturity model, as well as an organization-oriented maturity model (Weerdmeester et al. 2003). The RTD-oriented maturity model assesses the maturity of technology, while the organization-oriented maturity model appraises the human, organizational and general technological dimensions. Knowledge Management Formula (KMf) is a theoretical framework that shows how KM relies on a mix between Ki (organizational knowledge

infrastructure), Kc (knowledge culture) and Kt (knowledge technology) as shown in Figure 1.10.
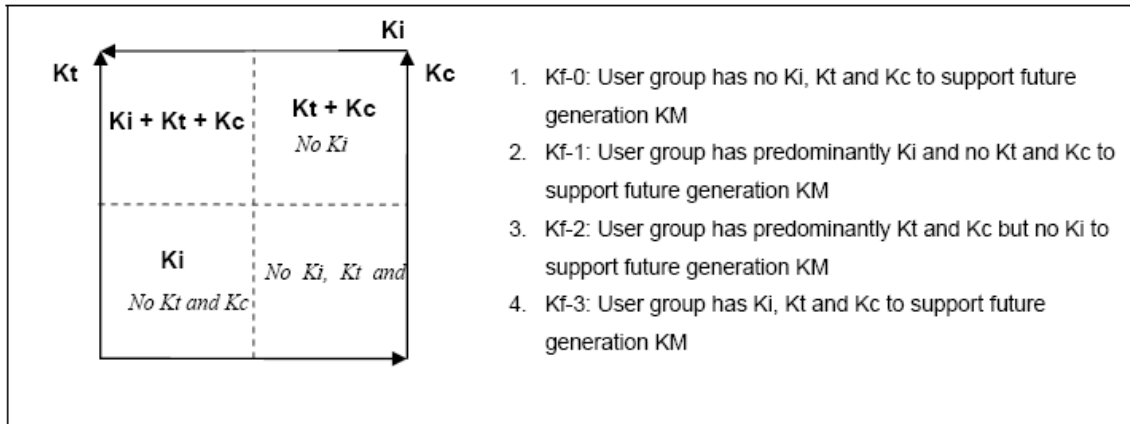

Figure 1.11: Knowledge Management Formula (KMf), Weerdmeester et al: 2003

5iKM3 KMMM of Tata Consultancy Services. The 5iKM3 KMMM is part of the TATA Consultancy Services' knowledge management strategy and identifies five states of maturity, namely initial, intent, initiative, intelligent and innovative. This can be achieved by addressing three key foundation areas (KFA), namely people, technology and processes. The 5iKM3 acknowledges that changes in the three KFAs would result in a change in maturity state and the impact would differ among KFAs and depend on the current maturity state.

Proposed Process Model for Knowledge Management

Applicability of CMM to Knowledge Management. This section defines a process model to describe the maturity of knowledge management in a Global Development Center (GDC) and uses the Capability Maturity Model (CMM) as the basis to create a model for assessing knowledge maturity in organizations. Although CMM is meant for describing software processes, researchers have suggested that it can be applied to KM maturity modeling. To the extent that software can be viewed as a knowledge medium, it is held that CMM can be adapted to the KM context (Armour: 2000, Paulzen and Perc: 2002, Khatbian et al: 2010). This can be applied to the area of knowledge management for the following reasons:

- The framework for CMM provides the capability to measure organizational rather than technological capability. Since knowledge management has a close link with people and process, this model is applicable for measuring the commitment of the organization and people, rather than a superior technical solution.

- The notion of maturity applies to knowledge management. The concept of "ensuring that an organization can operate at a maturity level" for a certain period of time is an excellent and systematic way of ensuring committed and complete implementations of the underlying concepts in an organization. Organizations

need to spend certain time at a maturity level to ensure that the knowledge management practices are fully internalized.

- The framework does not state the need for specific tools for implementation, but uses a model to ensure that practices are followed within the company. In the area of knowledge management as well, it has been clearly established that the tools and technologies provide the ability to create solutions. However, the success of the solution depends exclusively on the capability of the organization to enact the principles of knowledge driven organizations.

- The framework has been adapted for working on maturity of people practices in organizations. With the software oriented CMM, and the people CMM, an extension into the multi-disciplinary area of knowledge management provides a logical extension. In addition, the familiarity of terminology and assessment provides a basis for a robust model that can be applied in organizations.

The process model for knowledge management is a framework that describes the key elements of an effective organization that establishes formal knowledge management practices in a software organization. This describes an evolutionary improvement path from an ad hoc, immature process to a mature, disciplined process. The process model establishes a yardstick against which it is possible to judge, in a repeatable way, the maturity of an organization's knowledge management practices and compare it to the state of the practice of the industry. This can also be used by an organization to plan improvements to its knowledge management practices. As organizations establish and improve the knowledge management practices by which they approach the software development, they progress through levels of maturity. Each maturity level provides a layer in the foundation for continuous process improvement. Each key process area comprises a set of goals that, when satisfied, stabilize an important component of knowledge management practice. Achieving each level of the maturity model institutionalizes a different component in the knowledge management practice, resulting in an overall increase in the knowledge deployment and utilization capability of the organization. This thesis uses the available literature on CMM and related maturity models and creates a model for knowledge management by introducing specific themes aligned to the needs of knowledge management. This process model will be used as the basis for definition of an abstract specification for a system to assist in the implementation of the concepts.

Proposed Process Model. The proposed process model for knowledge management is defined along the lines of maturity in an organization. The current models have made a limited demonstrable linkage between software projects (the core business of software companies) and the knowledge management system. This is a critical link, since this offers an alignment between the principal business of a GDC and its knowledge management initiative and offers the ability to measure the success of the knowledge management initiative along business parameters. Knowledge management initiatives defined by the existing models assume that the benefits of the commitment will flow into projects. In addition, this aligns the work efforts of the people involved in the core business to the knowledge management related strategies pursued by the organization. In the current corporate environment, knowledge management process is not included

among the business processes. Therefore, employees always have no additional time or do not like spending additional time on knowledge management activities. It is the most emergent problem in current implementing knowledge management projects. Considering knowledge management process as a business process as well as integrating knowledge management process into the product development process is an approach to alleviate this challenge (Deng and Yu: 2006).

The goal is to define the model that is centric around its impact on software projects and integrating into the work practices followed by people executing the projects. Software organizations conduct their atomic unit of work in projects. Projects can be considered as well defined units of work to which a software organization applies resources of people, technology, process, infrastructure and (possibly) knowledge Projects also form the unit of implementation of key practices in a software organization. In as much as the organization of projects facilities the management of output to ensure conformance to schedule, budget and ensures process standardization, it also results in decentralization and knowledge fragmentation (Disterer: 2002). For that reason projects have to adapt knowledge and experiences from the daily work of a company within the routine organization and from former projects. There is routine interaction between the project organization and the underlying routine organization as shown in Figure 1.11 below.
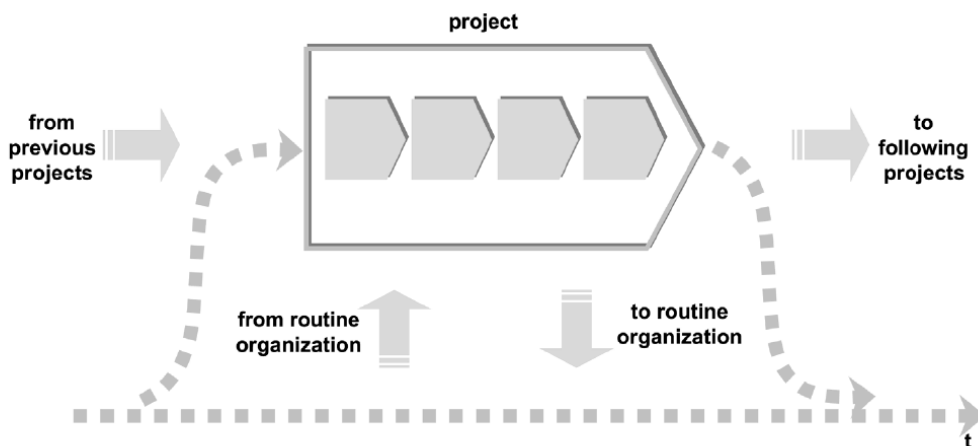
Figure 1.12: Interaction between projects and an underlying routine organization (Disterer: 2002)

The proposed model considers this to be the seminal problem of knowledge management as it applies to software organizations. In such a case, specific steps need to be taken by the software project organization to reach out to existing sources of knowledge. On the other hand, knowledge management initiatives supported by the organization must have an impact on the economic measures of a project. Any knowledge initiative must have its benefits appear in the execution of projects, since that is the organizational unit that actually creates or modifies software. Such benefits can be measured in terms of standard metrics that are defined for software projects. Examples of benefits include improved time to deliver a project, reduced defects in a project and reduced cost (effort)

in developing a project. This linkage is fundamental to the measurement of the benefits of a knowledge management initiative and provides an answer to the claims that outcomes of knowledge management initiatives are not measurable (Pee et al: 2006). Once the knowledge management practices are embedded into projects, the organization can then seek to take a holistic view of related knowledge management practices needed to consistently drive benefits at the project level. In such a case, the local implementation will benefit a project, and the aggregated benefits will be visible at the organization level. In such a case, the process model for knowledge management co-exists and is tied to the organization's fundamental processes associated with software development.

Level 1 - The Initial Level

At the Initial Level, the organization typically does not provide a stable environment for knowledge management as it relates to software development in a GDC. When an organization lacks an approach to knowledge management, most of the knowledge related events are purely ad-hoc, and rely merely on individual initiatives. There is minimal orientation towards reuse of software and standardized, proven solutions. All the software is written from scratch-up. Prior knowledge is not available to the current domain, even if the problem may have already been encountered in the organization. There are no formal structures for storage of knowledge in the project and the organization. This translates to ad-hoc and variable performance of the team members in problem solving approach. The level of domain knowledge, technology knowledge, and process knowledge is ad-hoc and there are no systematic processes for storage, retrieval, and dissemination for knowledge in the projects. Success depends entirely on having an exceptional talent. The knowledge management capability of Level 1 organizations is unpredictable because the knowledge management process is ad hoc.

Level 2 - The Repeatable Level

At the Repeatable Level, the focus is on processes at the project level. This is a simple, yet critical linkage to the unit or production in a GDC, and permits alignment of all knowledge management practices to an impact at the project level. The basic knowledge management practices for a software project are established. There is a planned effort to define knowledge needs for a project and to seek specific knowledge at the beginning of the project. New projects make an attempt to include knowledge that has been created in organization in other efforts. There is a commitment to apply the knowledge that has been located based on the defined knowledge needs in the project. Created knowledge artifacts are archived at the end of the project. A basic knowledge repository exists that collects all knowledge artifacts for the organization. One objective in achieving Level 2 is to implement effective knowledge management processes at the project level, which allow organizations to apply successful knowledge derived on earlier projects, although the implementations by the projects may differ. The project manager and the project team are aware of the knowledge management practices and understand its context in the software project. The knowledge management capability of Level 2 organizations can be summarized as disciplined because knowledge need is defined, knowledge fulfillment is

attempted, and knowledge is captured at a project level and stored in a knowledge repository for later use.

Level 3 - The Defined Level

At the Defined Level, the standard process for knowledge management practices across the organization is documented at the project and the organization level, and these processes are integrated into a coherent whole. Knowledge management practices at the project level are integrated into organization-wide practices that provide underlying support to the usage of knowledge in projects. There is a group that is responsible for the organization's knowledge management activities to coordinate organization wide initiatives in knowledge management. People practices are implemented to ensure that the staff and managers know how to apply knowledge management practices in software projects. Projects leverage the knowledge created in other parts of the organization to apply, for solutions in their specific context. There is an assigned group to enrich the knowledge that is created in projects. There is formalism to ensuring that knowledge is periodically reviewed and enriched to maintain currency and reflect applicability. Knowledge representation is addressed formally to ensure standard classification, and there is a group assigned to ensure coordination across the organization. Technology initiatives are funded to support the knowledge management practices. There is an assigned group to focus on technology initiatives within the organization. This is based on the fact that software organizations are often dispersed across multiple locations, and often seek global solutions with teams working in multiple geographic locations working on the solutions. In such a case, creation can happen at different parts of the organization, and technology is needed to provide the ability to capture, locate, and disseminate knowledge in such an organization. Because the knowledge management process is well defined, management has good insight into its implementation on all projects.

The capability of Level 3 organizations can be summarized as standard and consistent because knowledge management activities are stable and repeatable with a commitment to implement in a standard manner across all projects in the organization. There is a well- defined support and focus on the organization's part on the structures needed to implement knowledge management effectively at the project and the organization level. This capability is based on a common, organization-wide understanding of the activities, roles, and responsibilities in a defined process.

Level 4 - The Managed Level

At the Managed Level, the organization sets quantitative goals for knowledge management. This is used to ensure that key measurements are in place to ensure that the business goals are met with the knowledge management practices. There is recognition that knowledge from external key constituents has a role to play. This could include information from customers, partners, and vendors involved in crafting a solution. Knowledge management practices from within the organization are extended to key partners to ensure that greater knowledge benefits accrue. The organization recognizes

the role of communities of practice as the critical building block for building a knowledge culture and driving the enrichment and transfer of knowledge.

The process capability of Level 4 organizations can be summarized as managed with the communities of practice, external integration, and quantitative approach acting as the foundations for knowledge classification and dissemination.

Level 5 - The Optimizing Level

At the Optimizing Level, the entire organization is focused on continuous process improvement using knowledge management principles. The organization drives a commitment to foster a knowledge market as the basis of knowledge exchange within an organization, and derive all the benefits of effective practices. In addition, there is complete capability to manage shifts in innovation, and incorporate the innovations into the organization in a systematic manner. The knowledge management framework forms the fundamental underpinnings of the organization, which now has the capability to provide rapid solutions using existing expertise and solutions.

The process capability of Level 5 organizations can be characterized as continuously improving because Level 5 organizations are continuously striving to improve the range of their knowledge management capabilities. Improvement occurs both by consistent focus on creating knowledge markets and by incorporating new innovations.

Figure 1.12 shows the maturity levels in the proposed model. Table 1.3 provides the maturity levels and the associated key process areas.
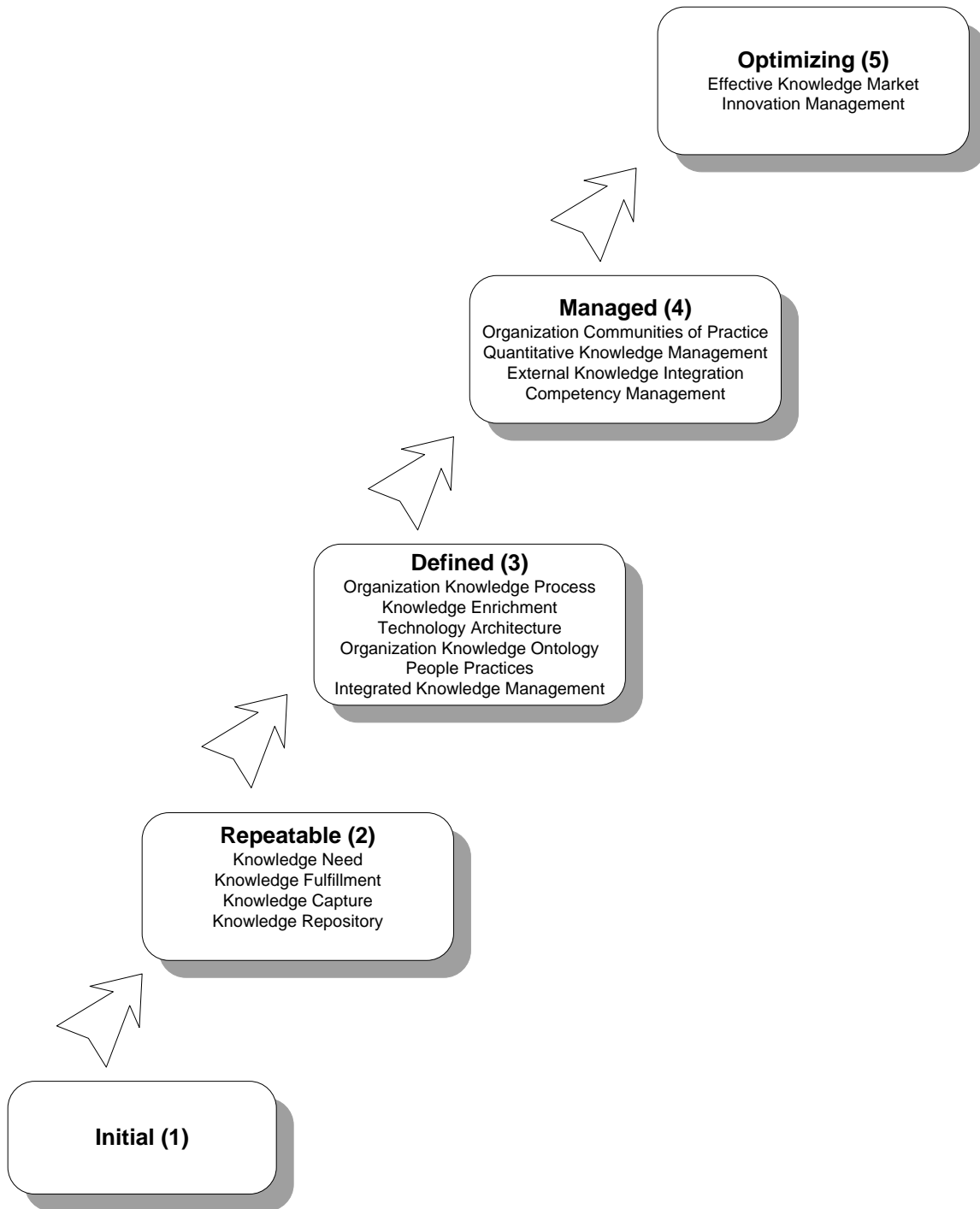
Figure 1.13: Key Process Areas by Maturity Level

Table 1.3: Key Process Areas for the Process Model

Maturity Level	Key Process Area
Initial	None
Repeatable	Knowledge Need
	Knowledge Fulfillment

	Knowledge Capture
	Knowledge Repository
Defined	Organization Knowledge Process
	Knowledge Enrichment
	Technology Architecture
	Integrated Knowledge Management
	Organization Knowledge Ontology
	People Practices
Managed	External Knowledge Integration
	Organization Communities of Practice
	Quantitative Knowledge Management
	Expertise Management
Optimizing	Effective Knowledge Markets
	Innovation Management

Organizational Roles and Structure

Although the CMM attempts to remain independent of specific organizational structures and models, it is necessary to express the practices in the CMM consistently using terminology related to organizational structure and roles, which may differ from that followed by any specific organization. A role is a unit of defined responsibilities that may be assumed by one or more individuals. The roles frequently used in the key practices are manager, senior manager, project manager, staff and individuals (Paulk et al: 1993).

The fundamental concepts of organization, project, and group must be understood to properly interpret the key practices of the Capability Maturity Model. An organization is a unit within the GDC within which many projects are managed as a whole. The organization has vested interest in ensuring the creation and sustenance of knowledge management practices. A project is an undertaking requiring concerted effort, which is focused on developing and/or maintaining a specific product. Projects create knowledge and use knowledge to perform tasks. A group is the collection of departments, managers, and individuals who have responsibility for a set of tasks or activities. Groups commonly referred to are described below:

- Knowledge Management Process Group: The knowledge management process group is responsible for definition, maintenance and improvement of knowledge processes used by the organization.   This group works towards the implementation of organization and project level processes for knowledge management in an organization.

- Knowledge Expert Groups: The knowledge expert groups are a set of groups that consist of experts in specific areas. The expert groups consist of one or more members who are designated and acknowledged as experts in a specific domain. Examples of areas of expertise include technology, process management, project management, or specific business domains. This group is responsible for

enriching knowledge artifacts, and works towards enhancing the inherent knowledge within an organization.

- Knowledge Ontology Group: The knowledge representation group works towards standardization in representation and interchange of knowledge in an organization. This can be a dedicated group or a group that composes of domain experts with a knowledge representation coordinator to ensure that a standard definition of terms can be created and maintained in the organization.

- Technology Group: The technology group is responsible for planning and implementing technology solutions to support the knowledge management program. This group is responsible for making choices on specific technology and tools that will best meet the needs of the organization, and facilitate the implementation of these into the mainstream organization.

Process Model Mapping

Thematic Mapping. There are four themes that run across the creation of the key process areas in Knowledge-CMM. These have been described with the mapping to the proposed maturity model in Table 1.4.

Table 1.4: Thematic Mapping

Theme	Key Process Areas
Organization Processes: These practices define the commitment of the organization to ensure that knowledge management practices are implemented consistently in the organization.	Level 3: Organization Knowledge Process, and Integrated Knowledge Management Level 4: Quantitative Knowledge Management
Knowledge Processes: These practices bring in specific knowledge management themes that need to be carried out at the organization and project levels.	Level 2:Knowledge Need, Knowledge Capture and Knowledge Fulfillment Level 3: Knowledge Enrichment, and Organization Knowledge Ontology Level 4: External Knowledge Integration Level 5: Innovation Management
People Processes: These practices bring in specific people related themes that to create a knowledge-oriented culture within the organization.	Level 3: People Practices Level 4: Organization Communities of Practice, Expertise Management Level 5: Knowledge Markets
Technology Processes: These practices bring in technology themes that focus on creating processes that focuses on leveraging technology.	Level 2: Knowledge Repository Level 3: Technology Architecture Level 4: External Knowledge Integration

Domain Mapping. Xerox, American Productivity & Quality Center, Ernst and Young did a study of 40 case studies in the area of knowledge management and Boston College based on the engagements with customers and arrived at the following ten domains (Holtshouse: 1999). These have been mapped to the proposed model in Table 1.5.

Table 1.5: Domain Mapping

Domain	Key Process Areas
Sharing knowledge and best practice	Level 2: Knowledge Fulfillment, Level 3: Knowledge Enrichment, Level 4: Organization Communities of Practice
Instilling responsibility for knowledge sharing	Level 3: Organization Knowledge Process, Level 4: Organization Communities of Practice
Capturing and reusing past experience	Level 2: Knowledge Need, Knowledge Fulfillment, Knowledge Capture, Knowledge Repository, Level 3: Knowledge Enrichment
Embedding knowledge in service, products and processes	Part of the core business, Level 2: Knowledge Capture
Producing knowledge as a product	Knowledge may not be product – however, Level 4: Expertise Management addresses expertise buildup
Driving knowledge generation for innovation	Level 4: Expertise Management, Level 5: Innovation Management
Mapping network of experts	Level 2: Knowledge Repository, Level 3: Knowledge Enrichment, Level 3: Organization Knowledge Ontology
Building and mining customer knowledge bases	Level 2: Knowledge Repository, Level 3: Organization Knowledge Ontology
Understanding and measuring the value of knowledge	All levels contain measurements that are expected to reflect the economic benefits of knowledge management processes.
Leveraging intellectual assets	Level 2: Level 2: Knowledge Need, Knowledge Fulfillment, Knowledge Capture, Knowledge Repository, Level 3: Knowledge Enrichment

Chapter 2: The Process Model

Key Process Areas

The process model for knowledge management integrates the human-centric and technology centric approach for a GDC organization, an approach that is recognized as being more holistic in approach in terms of codification and personalization, engineering and community, knowledge worker and expert, document management and skill management (Maier and Remus: 2003, Pumareja and Sikkel: 2005, Thomas et al: 2001, Cross and Baird: 2000). The essential components of the process model are used as to create the specifications and the prototype in the next sections.

The process model defines key process areas along the definitional components of the Capability Maturity Model. The key process area includes a rationale that provides the context and general information for definition of that area. It then goes on to provide details of the process area using the same structure as that of the capability maturity model.

Level 2 Key Process Areas

Knowledge Need

Rationale

The purpose of Knowledge Need is to provide the project team the capability to determine and outline the knowledge needs of a project in a planned and systematic manner. This provides a comprehensive approach to knowledge acquisition based on usage (Komi-Sirviö et al: 2001). Workflow for a project can start with an unresolved problem, which can be used to access the organization system to seek a solution (Salisbury: 2003). Knowledge needs at beginning of project could include evaluation of new ideas, review of lessons learned, project plans and budgets, best-practice documents and task packages (Hanisch et al: 2009). The inputs for the knowledge needs can come from multiple sources such as the requirements document, the problem domain, statement of work, and different aspects of the solutions. Knowledge needs can arise out of the technical and functional areas in the project as well as specific process and project-centric needs for a project. Knowledge needs in development projects could include process overview, task overview including pre- and post-conditions for performing tasks, lessons learned, general software engineering and applicable artifacts, while the needs in maintenance could focus on artifacts that require specific attention related to maintainability (Havelice et al: 2009). A specific form called a knowledge map can be been created to capture knowledge needs at the beginning of a project (Pandey and Dutta: 2013). The knowledge needs could be as diverse as the need for architecture and frameworks for creation of the software product, to guidelines and "how-to" for the use of new tools in the software project. Knowledge needs can also arise for expertise or people who have worked in similar areas in the past. Alternately, knowledge needs may

want to understand lessons learned from similar projects executed in the GDC. Knowledge needs can arise at various stages of the project. At each stage, the needs may reflect the life-cycle phase of the project at that time. The knowledge needs of a project are created during the course of the project using a defined approach for specifying the needs. Knowledge needs define the requirements of the knowledge management system from the viewpoint of the specific project at hand. The principal goal of the knowledge management system is to attempt to create a material impact by provisioning applicable knowledge resources such as artifacts and expertise to the project to create an economic impact in the project. Typically, this economic impact will be in terms of reduced effort and cost, improved timelines for delivery, and reduced error rates in the delivered project.

Goals

1. Knowledge needs for the project are formally established at the beginning of the project and at other time as needed in the project. Knowledge needs for a project are formally tracked.

2. Affected groups and individuals agree to their commitments related to knowledge related activities.

Commitment to perform

1. The project team has been allocated the responsibility for establishing the knowledge needs of the project.

2. The documents or system that is used for the basis for representing the knowledge needs of a project are well defined. The project manager and appropriate team members may include other groups in identifying the knowledge needs for the project. Knowledge need is established at the beginning of the project, and at periodic intervals, based on the changing needs of a project.

3. The knowledge needs of the project are formally tracked, managed and controlled with an appropriate level of documentation.

Ability to perform

1. A well-defined set of inputs exist that act as the requirements for the knowledge needs of the project. This may include statement of work, requirements documentation, related documentation and causal communication such as mails and memos that outlines the needs of the project. These inputs will be used to create the knowledge needs.

2. Responsibilities for determining and monitoring the knowledge needs are assigned formally. Project team members are assigned to create the knowledge needs for the project and have the ability to define the knowledge needs based on the available information in the project. The team is aware of available knowledge resources in the organization. Examples of knowledge resources are

software and process artifacts, human expertise, existing communities and external sources of information.

3. There is awareness of knowledge management and its implied benefits across team members in the organization. This team is oriented to the overall benefits of applying prior knowledge for the project. Examples of benefits are reduced time for development, reduced number of defects due to use of pre-fabricated solutions, reduced user acceptance issues due to greater domain knowledge.

Activities performed

1. The project team participates in the early stages of the project, including the project proposal process to identify knowledge needs. Where relevant, other groups can be involved. The project team gains an early awareness of the knowledge needs by participating in the initial stages of the project.

2. Knowledge needs are captured in a formal and defined manner. The knowledge management process group and knowledge expert group act as the coordination group to assist the team in outlining the knowledge needs, where relevant.

3. The project manager and the project team conduct formal reviews to review the knowledge needs that are defined.

Measurement and analysis

1. Measurements are made to understand the knowledge needs of a project. Examples of measurement include the number of knowledge needs identified in a project, the nature of knowledge resources defined in the knowledge need, the areas and domains reflected in the knowledge need.

Verifying implementation

1. The activities of knowledge need for a project are reviewed on a periodic basis.

Knowledge Fulfillment

Rationale

The purpose of knowledge fulfillment is to provide the project manager the capability to have a systematic and formal approach for the fulfillment of the defined knowledge needs in a project. Knowledge fulfillment represents the commitment of the project to attempt to fulfill the defined knowledge needs defined for the project. Knowledge fulfillment requires the ability to identify appropriate and applicable knowledge resources that can fulfill the knowledge needs of a project and ensure that such knowledge is disseminated and used in the project. This provides specific focus on ensuring that already created knowledge in the organization can be applied to the "new" project at hand. The motivation for this is the availability of a set of "proven" artifacts and expertise that can

be used for the project. The project manager and the project team can assess the available knowledge and determine whether this will create the needed economic impact in the project. For instance, an already available artifact may be suitable for the project with minor modifications for use in the project. In such a case, the project may benefit from reduced effort and cost associated with the creation of that artifact. Alternately, an already tested artifact may be found that can result in reduction in defects. Knowledge that is determined to be useful can then be formally disseminated to the individuals of the project and used in the project. Knowledge fulfillment will include specific methods in which knowledge can be disseminated in a project, and the follow-on activities that the project team will perform with the disseminated knowledge. Specific attention will be paid during project initiation and at specific milestones of a project. Knowledge fulfillment will also be tied into the project planning, since there is an opportunity to reflect the benefits in terms of schedule, cost and defects in various aspects of the project plan.

Goals

1. The project team has been assigned the responsibility for attempting to fulfill the knowledge needs of the project based on available organization resources. Where relevant, knowledge is disseminated to project team members.

2. The project manager must reflect changes in the project plan as a result of knowledge fulfillment.

3. Affected groups and individuals agree to their commitments related to knowledge related activities.

Commitment to perform

1. The project manager and project team members are responsible for attempting to fulfill the knowledge needs based on existing knowledge in the organization. Specific activities will be planned and executed to attempt to fulfill knowledge needs.

2. There is a documented approach for dissemination of knowledge. This includes the mechanism with an understanding of the type of knowledge (external or tacit) being disseminated.

3. The knowledge fulfillment for a project is formally tracked, managed and controlled against the underlying knowledge needs, with an appropriate level of documentation. The documentation reflects partially and completely fulfilled knowledge needs. Where relevant, the project plan will be updated to reflect the impact of available knowledge that can be used for the project.

4. Senior management reviews organizational knowledge gaps reflected by unfulfilled knowledge needs.

Ability to perform

1. Adequate resources are assigned to ensure that knowledge fulfillment takes place in the project in line with the knowledge needs. Knowledge experts and project team members from other projects may be called upon to assist in locating artifacts and information to help in fulfillment of the knowledge needs for the project. Decisions may need to be collaboratively made as to whether existing artifacts can partially or completely fulfill the knowledge needs of the project. This will require the project manager and the knowledge experts to review and reflect the impact of using existing knowledge on the project plan.

2. The dissemination of knowledge will require specific meetings and other techniques for dissemination to ensure that the individuals in a project have acquired the knowledge. Knowledge experts may provide structured knowledge dissemination sessions at various intervals in the project.

3. The project manager and team members are trained in basic communications and awareness for knowledge dissemination as a mode of operations in projects. They are trained in standards associated with the knowledge dissemination (presentations, documentation, and training). There is awareness of knowledge management and its implied benefits across team members in the organization.

Activities performed

1. The project manager and project team members will review existing organizational knowledge resources in order to attempt to fulfill their knowledge needs. Examples of knowledge resources include artifacts, experts, communities and external sources.

2. The project manager and project team members will make an explicit determination regarding the usage of existing knowledge resources. All fulfilled needs, partial and full, will be documented as part of the knowledge plan. The documentation will include reviewed knowledge resources. Project team members will assess the available artifacts and make a determination regarding the applicability of the artifacts to fulfill the knowledge needs for the project.

3. The project manager will update the project plan in case knowledge resources brought into the project impact the effort, cost, or schedule for the project.

4. Project team members will determine the usage of the knowledge resources that have been brought into the project. These will be disseminated to relevant team members, where relevant.

5. Knowledge experts will participate in the knowledge fulfillment and dissemination process, where they act as a source of fulfillment for a project. They will use appropriate techniques to disseminate tacit knowledge.

6. Formal reviews are conducted on the knowledge fulfillment and dissemination at periodic points in the project.

Measurement and analysis

1. Measurements are made to understand the status of the dissemination process. Examples of measurement include the percentage of knowledge needs fulfilled, number of dissemination sessions held, the number of artifacts used in the project, and the impact on the project plan.

Verifying implementation

1. The activities of knowledge fulfillment are reviewed with knowledge expert groups and senior management on a periodic basis to determine any knowledge gaps.

2. The project manager reviews the activities of knowledge fulfillment on a periodic basis.

3. The knowledge management process group conducts periodic reviews of projects to verify the knowledge fulfillment activities in a project.

Knowledge Capture

Rationale

The purpose of knowledge capture is to provide the project manager the capability to have a systematic and formal approach for the capture of knowledge that gets created during the course of the project. The nature of software development creates a natural alignment between knowledge creation and day-to-day work during the course of the project. This occurs as a consequence of created work-products in the project such as design specifications, database design, and programming code. In addition, lessons can be learned in a project. This area formally ensures that knowledge created in a project is captured and documented at specific milestones. This knowledge can then be used in other parts of the organization. Within the context of software projects, guidelines for the organization will be used to define what constitutes knowledge that needs to be captured. Mechanisms for capture of knowledge will be identified. Specific attention will be paid to the end of a project and significant milestones of the project. These are milestones where the capture will be formally addressed, in relation with the knowledge needs. In further levels of maturity, knowledge experts will participate in specific milestones to ensure that the knowledge created in the project has been fully captured.

This area attempts to capture knowledge after it has been formally used in the project. This allows prudent use of resources, since knowledge is generated and used in a project. At specific milestones, the recall of the team members who created the artifacts embodying the knowledge tends to be very high. This forms a natural milestone for capturing this knowledge. Knowledge capture formalizes this, and ensures that there is

an organization commitment to activities associated with knowledge capture. Well-documented knowledge capture provides a strong foundation for fostering knowledge enrichment and usage in communities of practice. As the organization matures in its knowledge management practices, project team members involved in the creation of the knowledge artifact can become members of the community of practice and enrich the knowledge created.

The concept of capturing knowledge at the end of a project has been recognized as an important step in the execution of projects. Recent literature and actual discussions indicate that project closing is becoming the most important phase to identify and to capture new knowledge and to prepare the knowledge for knowledge transfer to other projects (Disterer: 2002). Information captured can vary from formal artifacts to informal experiences in a project.

Goals

1. Knowledge created or acquired in a project is captured at periodic milestones in the project. Knowledge capture techniques for the project are planned and formally implemented.

2. The knowledge capture for a project are formally tracked, managed and controlled against the underlying knowledge needs, with an appropriate level of documentation.

3. Affected groups and individuals agree to their commitments related to knowledge related activities.

Commitment to perform

1. The project manager has been assigned the responsibility for planning and implementing knowledge capture for the project. The project follows a written organizational policy for capture of knowledge within a project. The knowledge capture is planned, managed and controlled.

2. There is a documented approach for capture of knowledge and a definition of the types of knowledge that will be captured. Examples of knowledge captured include:

   o Review notes that reflect the creation of the knowledge artifacts (not just the end artifacts themselves). Notes that provide further inputs into the thinking process of the creation of the artifacts.

   o Multi-media sessions that reflect the thinking process in the creation of artifacts.

   o Lessons learned in the project, which could include emails and discussions that provide specific information to support the lessons learned.

o Roles performed by different individuals in the project including specific artifacts of interest that were created by individuals.

3. The knowledge capture methods are negotiated between the project manager, and appropriate individuals in the team. This may include the knowledge experts in terms of technical and domain experts who are involved in the process of capture of knowledge.

4. Senior management does a periodic check to review the knowledge captured in a project, with a focus on the percentage of knowledge that was created in relation to the knowledge needs for the project.

Ability to perform

1. Project team members are assigned to ensure that knowledge capture takes place in the project. This includes the team members who were responsible for creating the knowledge in the project. These team members will package the created knowledge into forms that ensure that they can be easily disseminated for future use.

2. Knowledge experts participate in the knowledge capture to ensure that there is awareness of the knowledge created in a project. Knowledge experts have the ability to review and augment the lessons learned to assist in converting tacit knowledge into consumable forms for later use in the organization.

3. The project manager and team members are trained in basic communications and awareness for knowledge capture as a mode of operations in projects. They are trained in standards associated with the knowledge dissemination (presentations, documentation, and training).

4. There is awareness of knowledge management and its implied benefits across team members in the organization. This training will be oriented to the overall benefits of knowledge management for the project. In the training, the team can formally outline the economic benefits that they expect to derive out of the knowledge management practices. This could include specific benefits such as reduced time for development, reduced number of defects due to use of pre-fabricated solutions, reduced user acceptance issues due to greater domain knowledge and a tacit understanding of the business.

Activities performed

1. There is a formal method identified and followed for capture of explicit (easily documented) knowledge. This includes all software artifacts of relevance created in the project. There is clarity in the capture mechanism (document, presentation, spreadsheet, design of system in different language, etc). Various modes of capture are identified formally and followed in the capture process.

2. Knowledge experts ensure that the captured knowledge artifact is complete and can be disseminated. Tacit knowledge will be made external when knowledge experts have an opportunity to interact with the team members. In such a case, these knowledge experts will perform specific activities to externalize the knowledge.

3. The organization captures information associated with personnel and their roles in the project. Information is stored on creation and modification of specific artifacts by project team members.

4. The timing of capture is planned and adhered to formally. The capture plan is documented. The timing for capture is planned and ensures minimal loss of the value of the knowledge in the project. In some instances, special knowledge capture sessions are conducted immediately after creation of the artifacts to ensure accurate storage of the artifact.

5. At project closure, there is a review of all the knowledge artifacts created as part of the project. This is documented in the organization for subsequent retrieval.

6. There is recognition that knowledge gets created in the project when individuals make specific decisions and create software products. Post project analysis, defect cause codes and analysis, domain knowledge nuances, form part of the knowledge to be captured.

7. The knowledge management process group participates in reviewing the process and documents associated with the knowledge that has been created and captured in a project. They will match knowledge needs, knowledge fulfillment and knowledge capture for the project. This information will be used to determine whether the knowledge capture for a project is complete.

8. Formal reviews are conducted to ensure that knowledge has been captured in line with organization practices at periodic points in the project.

Measurement and analysis

1. Measurements are made to understand the status of the capture process. Examples of measurement include the number of capture sessions, the number of created artifacts, the number of tacit artifacts that have been reviewed by knowledge experts, the number of lessons learned.

Verifying implementation

1. The activities of knowledge capture are reviewed with senior management on a periodic basis.

2. The project manager on a periodic basis reviews the activities of knowledge capture.

3. The knowledge management process group conducts periodic reviews of projects to verify the capture of knowledge in a project.

Knowledge Repository

Rationale

The purpose of the Knowledge Repository is to provide the project manager the capability to store artifacts in a central repository. This central repository can be used to address the knowledge needs and determine knowledge fulfillment opportunities. The organization can use a variety of technologies to store knowledge. However, it is important that a set of technologies be selected and made available to the project teams in the organizations to ensure that consistency is followed in the storage of knowledge. The structure and content of the knowledge repository must be in line with the nature of knowledge that the organization would like to maintain. A dedicated group must be responsible for defining the structure of the repository and publishing the structure for use in the organization. Dimensions of the repository could include information on knowledge artifacts that are created in projects, information and structure about people and their experiences in software projects. The basic organization of the repository should permit the ability to retrieve all artifacts and information associated with a specific project. For this level of maturity, the organization must be able to retrieve all the artifacts for a specific project, and all project team members who have worked on a project. At later maturity levels, the classification scheme will be used to provide multiple dimensions to access the repository. The knowledge repository can be used in knowledge fulfillment and acts as the principal resource for the organization's knowledge.

Goals

1. Knowledge captured in the project is periodically stored in the knowledge repository.

2. Affected groups and individuals agree to their commitments related to knowledge related activities.

Commitment to perform

1. The project manager has been assigned the responsibility for storing knowledge in the knowledge repository. The project follows a written organizational policy for storing its knowledge in the knowledge repository.

2. The knowledge repository is managed and controlled in line with the organization's defined policy. The organization has assigned a group named the knowledge management process group for the oversight of the knowledge repository.

3. Senior management does a periodic check to review the knowledge repository to review the updates made to the repository.

Ability to perform

1. A well-defined set of guidelines are available to the project manager and project teams to ensure that they can store the knowledge in an appropriate manner in the knowledge repository.

2. There is awareness of the knowledge repository and its use in the organization. In the training, the knowledge management process group provides information on the structure and usage of the knowledge repository.

Activities performed

1. The project team stores the knowledge created in the project in the knowledge repository. Information on the number of artifacts stored is maintained.

2. The project team stores information in the repository associated with project team members and their roles in the project. Additionally, information on the artifacts created by team members is stored in the repository.

3. The knowledge management process group reviews the activities to ensure compliance with the organization policy for usage of the knowledge repository. This team works to manage the structure of the knowledge repository and ensures that this is managed and controlled.

4. Formal reviews are conducted to review the contents of the knowledge repository.

Measurement and analysis

1. Measurements are made to understand the usage of the knowledge repository. Examples of measurement include the number of artifacts added per time period, the number of artifacts added per project.

Verifying implementation

1. The growth and content of the knowledge repository are reviewed with senior management on a periodic basis.

2. The knowledge management process group conducts periodic reviews of the repository against completed projects to verify that knowledge is being stored in the repository.

Level 3 Key Process Areas

Organization Knowledge Process

Rationale

The purpose of organization knowledge process is to establish the organizational responsibility for processes associated with knowledge management activities. This involves developing and maintaining an understanding of the knowledge related assets and processes and coordinating the activities to assess, develop, maintain, and improve these processes. These assets may be created and collected in many ways. This area provides the long-term commitment of the organization to coordinate the development and maintenance of the knowledge processes for the organization via a group such as the knowledge management process group. This group is responsible for the development and maintenance of the organization's standard knowledge related processes, and it coordinates the process activities with the software projects. This group will work to tie in project related work to an organization's knowledge management processes. This group forms an integral part of defining processes at the organization level and facilitates the translation into project specific initiatives. This group will review knowledge management activities in the organization and provide a facilitative role for ensuring that knowledge management processes are followed.

Goals

1. The organization structure associated with knowledge management centric activities is formally defined and controlled.

2. Organization level process development and improvement activities related to knowledge management are planned. These practices are developed and maintained for the organization.

3. Information related to the use of the organization's knowledge management practices by projects is collected, reviewed, and made available.

Commitment to perform

1. The organization commits to a defined structure for knowledge management.

2. The organization follows a written organizational policy for the knowledge management process development and improvement activities. A group is established that is responsible for the organization-level knowledge management process processes. The knowledge management processes used by the projects are assessed periodically to determine their strengths and weaknesses. Improvements to, and other useful information on, each project's usage of the knowledge resources of the organization are available to other projects.

3. Senior management sponsors and oversees activities for knowledge management process development and improvement. They demonstrate commitment to these knowledge management process activities to the organization's staff and managers. They establish long-term plans and commitments for funding, staffing, and other resources. Strategies for managing, implementing and reviewing the activities for process development and improvement are established. They ensure that the organization's knowledge management process is integrated with the core business of software development. Senior management coordinates with the organization's managers to secure the managers' and staff's support and participation.

4. The organization follows a written policy for developing and maintaining standard knowledge management process assets. This policy typically specifies that a standard knowledge management process has been defined for the organization. The purpose is to review existing processes used for knowledge management activities and ensure that the best-practices used by different projects can be defined as standard practices to be followed in the organization. This will also provide the basic ability to define and aggregate a standard set of process measurements at the organization level. The organization's standard knowledge management process may contain multiple processes associated with knowledge creation, capture, configuration management, capture, and dissemination. Information collected from the projects is organized and used to improve the organization's standard knowledge management process. The organization's process assets include the following:

   o The organization's standard knowledge management processes used across projects and within the organization. Examples include processes associated with describing knowledge needs, knowledge capture, elicitation techniques, knowledge conversion between tacit and explicit states and so on.

   o The organization's knowledge process database consisting of a library of knowledge process-related documentation previously used and available for reuse.

Ability to perform

1. Senior management understands the goals of the knowledge management program and translates that into a structure within the organization.

2. A group named the knowledge management process group exists in the organization that is responsible for the organization's knowledge management process activities. Adequate resources and funding are provided for the organization's knowledge management process activities. Members of the group responsible for the organization's process activities receive required training to perform these activities. Examples of training include knowledge management practices, different knowledge processes used in software organizations, process control techniques, organization change management, planning, managing, and monitoring the knowledge management process and technology transition.

3. Members of other software-related groups receive orientation on the organization's knowledge management process activities and their roles in those activities.

4. Adequate resources and funding are provided for developing and maintaining the organization's standard knowledge management process and related process assets. The development and maintenance of the organization's standard knowledge management process and related process assets is performed or coordinated by the knowledge management process group. Tools to support process development and maintenance are made available. Examples of support tools include desktop publishing tools, database management systems, and process modeling tools. The individuals who develop and maintain the organization's standard knowledge management process and related process assets receive required training to perform these activities.

Activities performed

1. Senior management defines a formal structure for managing knowledge in the organization. A group, such as the knowledge management process group, can be setup to manage the structure on a periodic basis.

2. The set of defined knowledge management processes are developed based on the needs of the organization and processes periodically, and action plans are developed to address the assessment findings. An assessment looks at all processes used in the organization and identifies opportunities for improvement. The action plan identifies assessment findings that will be addressed, guidelines for implementing the changes to address findings, and identifies groups or individuals responsible for implementing the changes.

3. The organization develops and maintains a plan for its knowledge management process development and improvement activities. This plan defines the activities to be performed and the schedule for these activities. The groups and individuals responsible for the activities, along with the resources needed are identified. This plan is reviewed internally and is reviewed and agreed to by the organization's managers. The organization and project activities for developing and improving their knowledge management processes are coordinated at the organization level.

4. The use of the organization's knowledge management process database is coordinated at the organizational level. The organization's knowledge management process database is used to collect information on the knowledge management processes and resulting process products. New processes, methods, and tools in limited use in the organization are monitored, evaluated, and, where appropriate, transferred to other parts of the organization.

5. Training for the organization and projects' knowledge management processes is coordinated across the organization. The groups involved in implementing the

knowledge management processes are informed of the knowledge management process development and improvement.

6. The standard knowledge management process is developed and maintained according to a documented procedure. This procedure typically specifies that the process satisfies the policies, process standards, and product standards imposed on the organization, as appropriate. The internal process interfaces between the knowledge management areas are described. The external process interfaces between the knowledge management process and the processes of other affected groups are described. Changes proposed are documented, reviewed, and approved by the group responsible for the organization's process activities (e.g., knowledge management process group) before they are incorporated. Plans for introducing changes to the knowledge management process of ongoing projects are defined as appropriate. The description of the organization's standard knowledge management process is placed under change management.

Measurement and analysis

1. Measurements are made to understand the status of the organization process focus and definition process. Examples of measurement include review of the standard process, number of modifications made, schedule and cost of creating this process.

Verifying implementation

1. The activities of knowledge organization process focus and definition are reviewed with senior management on a periodic basis.

Knowledge Enrichment

Rationale

The purpose of knowledge enrichment is to have a formal and defined approach for the enrichment of the created knowledge in a project, to ensure that it has greater wide-spread use in an organization. Knowledge enrichment ensures that the organization is committed to allocating organizational resources in the form of "people expertise" to work on the artifacts created in a project. Enrichment of the artifacts could range from a simple commentary of the artifact, an assessment of the artifact, and modifications that would allow the artifact to be used for general purpose. Enrichment occurs when experience is captured in the artifacts – as an example software inspection can also be looked at from another interesting viewpoint, as it provides an effective means of acquiring and reusing experience knowledge (Kokkoniemi: 2006). This will permit the organization to create an expert-endorsed set of knowledge artifacts, with the assurance that the knowledge created in projects has been formally assessed for its accuracy and contents. This will ensure that any captured knowledge is worked on and documented formally as per the defined standards and guidelines within the organization. The original and modified artifacts will be stored with adequate documentation on the

enrichment that has been carried out in the artifacts. Specific attention will be paid to the end (project closure) of a project. Typically, these are time points in a project where the maximum artifacts are available for knowledge enrichment. The goal of knowledge enrichment will be to retain only the relevant contextual content in the knowledge artifacts to ensure more universal usage and adaptation of the artifacts. The expected economic impact of knowledge enrichment is the usage of the artifacts in a future project.

Knowledge Enrichment ensures that the knowledge cycles get reflected in the process framework. This process area permits the transfer of knowledge between tacit and explicit states. Knowledge enrichment ensures that designated experts participate in capturing tacit knowledge that has been created in a project and ensuring that such knowledge captured in an organization is adapted for greater widespread use. Knowledge enrichment embeds the themes associated with a lessons learned system. Knowledge enrichment can focus in all four quadrants of the transformation process shown in Figure 2.1. In addition to participation in the transfer of knowledge states, knowledge enrichment includes knowledge assessment and endorsement. The knowledge expert group works with project teams to assess the knowledge artifacts created as part of the project, and provides an assessment that is available to the organization. For this to happen, the knowledge experts have to formally participate at those points in a project where knowledge is created. The role of the knowledge experts in knowledge enrichment is to ensure that the knowledge captured in projects can be transformed into artifacts with greater use in the organization. Knowledge enrichment areas are stated below:

- Knowledge artifacts created from projects may be pared down to expose the "highest" knowledge content in these artifacts.

- The context of the project (which may have limited value, and act as noise in applying the knowledge artifact) may be eliminated from the artifact. The artifact may be abstracted by modifying the contents.

- An assessment commentary can reflect the core usage of the artifact. This can include information on the strengths and limitations of the knowledge artifact with a guide for applicable usage.

- If the artifacts have inherent limitations due to the nature of the project, knowledge enrichment will apply resources to ensure that it is worked on to enhance the contents to overcome these limitations.

- Knowledge classification can be reviewed and modified to ensure that the artifact's dimensions of prospective usage can be accurately represented in the knowledge repository.

- There may be artifacts that have tacit knowledge, in terms of assumptions in the creation of the artifacts. Knowledge experts will work with the project teams at the end of the project to expose these assumptions so that the tacit knowledge can be externalized beyond the specific project.

- Multiple artifacts can be combined by knowledge experts to create a complex knowledge artifact.

This is a significant organization-centric cultural building block, specifically for software organizations. It is widely recognized that directions (technology, business vertical, process, and management related) within a software organization tends to follow the expertise route, rather than the designation route. Typically, software engineers are more prone to follow the advice of an expert, rather than a manager, when it comes to technical decisions. This KPA hinges around this fact, and uses knowledge experts as the basis for creating a basic vehicle for enriching, endorsing and assessing the knowledge created in projects. This also legitimizes and endorses the activities and participation of expertise in the context of software development. As part of this, the Level 2 areas will get greater attention and focus from knowledge experts.

	Tacit		Explicit	
	Socialisation "Collect"		**Externalisation** "Verify & Store"	
Tacit	Features 1. Add lessons learned 2. Online Discussion	▪ New lessons can be added by any member of the group ▪ Group members can interact online before adding new lessons	Features 1. Verify 2. Save 3. Delete	▪ Verification is done on each added lessons by "expert" ▪ These 3 features are only accessible to "experts" ▪ Translate tacit knowledge into "comprehensible" form
	Internalisation "Reuse"		**Combination** "Dissemination"	
Explicit	Features 1. Search by category 2. Search by keyword 3. Print 4. Download	▪ Lessons can be searched by members only ▪ Can be transformed into other media through print and download feature (to absorb tacit knowledge into "actionable" form	Features 1. Host on website with user authentication 2. Newsflash on latest verified lessons	▪ Done by moderator/ADMIN (a member of the group) with advise from "experts"

Figure 2.1: Activities in a Lessons Learned System (Sharif et al: 2004)

Goals

1. Knowledge enrichment techniques for the organization are developed and maintained.

2. Knowledge artifacts captured as part of projects are collected, reviewed, and used in the knowledge enrichment for the organization.

3. Certain activities at Level 2 of the organization have defined participation by knowledge experts.

4. Affected groups and individuals agree to their commitments related to knowledge enrichment related activities.

Commitment to perform

1. The organization establishes a set of groups that are designated to be responsible for the knowledge enrichment of the organization. Such groups will typically be a set of knowledge expert groups, with specific expertise in the areas where knowledge enrichment is aligned to the business of the company.

2. The organization follows a written policy for enrichment of knowledge. This will be part of the organization's standard knowledge management process. This will take into account the fact that knowledge is captured as part of projects and enrichment of the captured knowledge will be coordinated and managed by the knowledge expert group. There is a documented approach for enrichment of knowledge.

3. Senior management does a periodic check to review the knowledge enrichment practices and ensure that this meets the business goals of the organization. Senior management takes the direct responsibility for establishing knowledge expert groups aligned with the business needs. Senior management does a periodic review of the work products produced by the knowledge expert groups in the knowledge repository as it relates to fulfillment of knowledge needs in an organization.

Ability to perform

1. Adequate resources are assigned to ensure that knowledge enrichment takes place in the organization. This includes the knowledge experts that are responsible for enriching the knowledge that has been created in the project. Knowledge experts will have the designated authority to participate in knowledge related activities of a project related to their area of expertise.

2. The project manager and team members are trained in the role and need for knowledge experts in an organization. The team members who have created the knowledge artifacts understand that they need to work with the knowledge experts to ensure that knowledge enrichment takes place.

3. There is awareness of knowledge enrichment and its implied benefits across team members in the organization. This training will be oriented to the overall

benefits of knowledge enrichment for the organization and the role of the project in such an activity.

4. The knowledge expert group is responsible for conducting knowledge enrichment sessions. Their participation is to ensure that the organization norms for different aspects of knowledge enrichment are followed.

Activities performed

1. There is a defined approach that is followed for enrichment of knowledge. This is part of the organization standard knowledge management process. The approach includes the guidelines associated with knowledge enrichment. The responsibilities of the knowledge expert group in knowledge enrichment and the project team members are outlined. Information guidelines on the documentation regarding knowledge enrichment are included for different aspects of knowledge enrichment. Specific information is included on storage of the original and modified versions of the knowledge artifacts. The process of enrichment is managed and controlled.

2. The timing of enrichment is planned and adhered to formally. Once the knowledge artifact is captured within a project, there is a defined periodicity for the enrichment of knowledge. Knowledge experts will participate to assess and enrich the knowledge artifacts.

3. Knowledge experts perform the enrichment of knowledge as per the defined norms for the organization. Activities include one or more of the following:

    o Provide assistance in defining the knowledge needs for a project based on the problem statement for the project.

    o Providing knowledge artifacts and expertise to fulfill knowledge needs belonging to their area of expertise. Provide specific information and guidance on how existing artifacts can be modified to meet the needs of a specific project. In addition, knowledge experts may assist the project manager is estimating the effort, cost, and quality parameters of the organization in using existing artifacts vis-à-vis developing the artifacts.

    o Directing the project teams to review and use specific artifacts in the knowledge repository that may be applicable to fulfill a specific knowledge need. Knowledge experts may assist in the modification and adoption of existing artifacts by working with the project teams.

    o Participating at knowledge capture at periodic intervals in the project. Activities include all aspects of knowledge enrichment including knowledge assessment, socialization, combination, internalization, externalization, abstraction, and modifications.

4. Formal reviews are conducted to address the accomplishments of knowledge enrichment at periodic points by senior management. The knowledge

management process group will conduct periodic reviews of knowledge enrichment processes and activities.

Measurement and analysis

1. Measurements are made to understand the status of the knowledge enrichment process. Examples of measurement include the number of artifacts that have been enriched, artifacts modified, tacit knowledge captured, cost and schedule for the knowledge expert group.

Verifying implementation

1. The activities of knowledge capture are reviewed with senior management on a periodic basis.

2. The knowledge management process group conducts periodic reviews of to verify process conformance of the knowledge enrichment process.

Technology Architecture

Rationale

The purpose of the Technology Architecture key process area is to ensure that there is a defined strategy for the use of technology and corresponding investment in the appropriate technology architecture to support the knowledge management initiative. This involves the creation of a plan associated with the technology architecture that is needed for the implementation of effective knowledge management practices. The definition of the plan will take all the dimensions of the organization into account, and establish a plan for the selection and implementation of technologies that will adequately support the knowledge management program. Different technologies that can be considered will be evaluated and the requisite infrastructure will be created as per the plan. The technologies considered will be in line with the size and geographical dispersion of the organization. This key process area recognizes the role of technology in knowledge management and requires an organization to make a formal plan associated with the implementation of technology architecture.

Knowledge management requires appropriate technology architecture to support its implementation. This can use formal methods to define the architectural quality attributes for the organization in order to determine the components needed for implementation. Technology can address two important considerations in managing knowledge, shown in Figure 2.2 - where the knowledge resides and the extent to which the knowledge is structured. The locus of the knowledge determines whether the technology solution connects a user who has a problem or question to an artifact or directs her to a person. The level of a priori structure determines the extent to which the system imposes the burden of a translation or transformation of the problem or question to a form that corresponds to implicit logic underlying the a priori structure (Hahn and Subramani: 2000). Figure 2.3 provides a representative mapping of technologies that can address

different processes in a knowledge management program. Figure 2.4 shows a possible view of the system architecture for a knowledge management system.
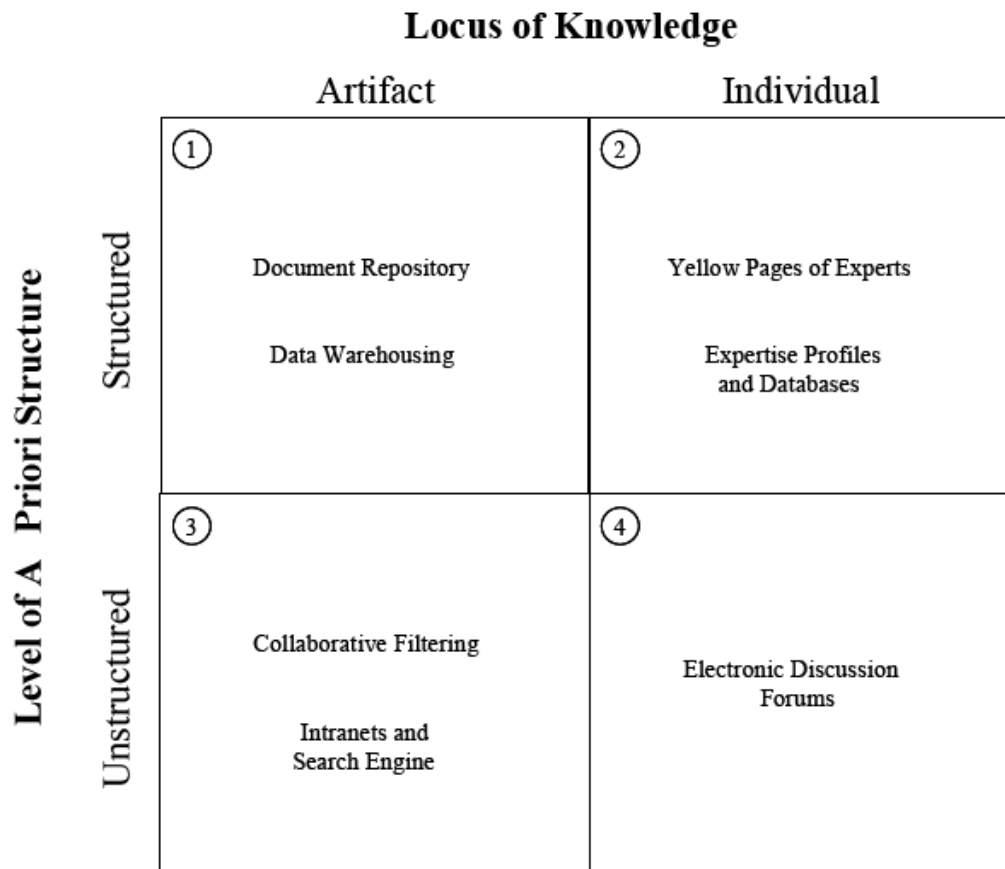
Locus of Knowledge

Figure 2.2: Technology Framework for Knowledge Management Support (Hahn and Subramani: 2000).
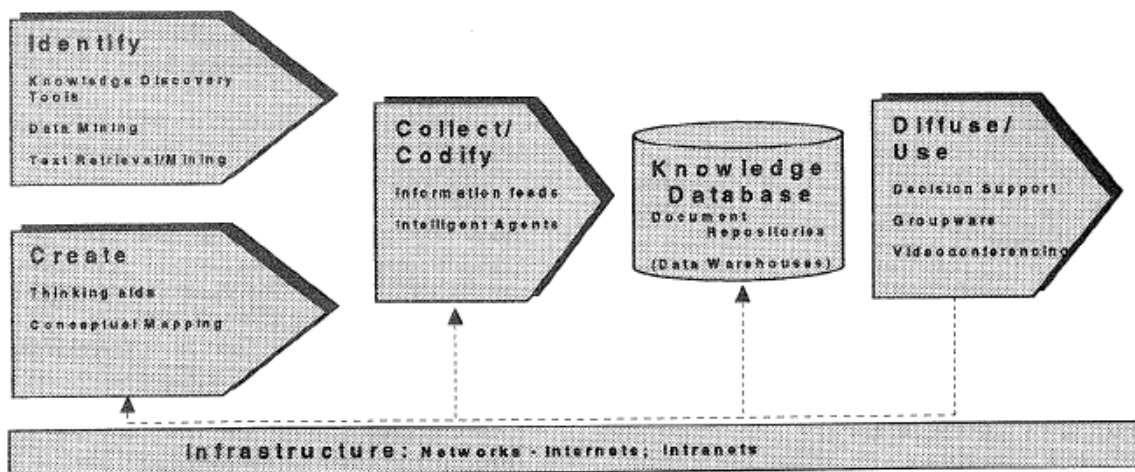
Figure 2.3: Representative technology solution for a knowledge management program (Skyrme: 1998)

Figure 2.4: Sample Knowledge Management Architecture (Lawton: 2001)
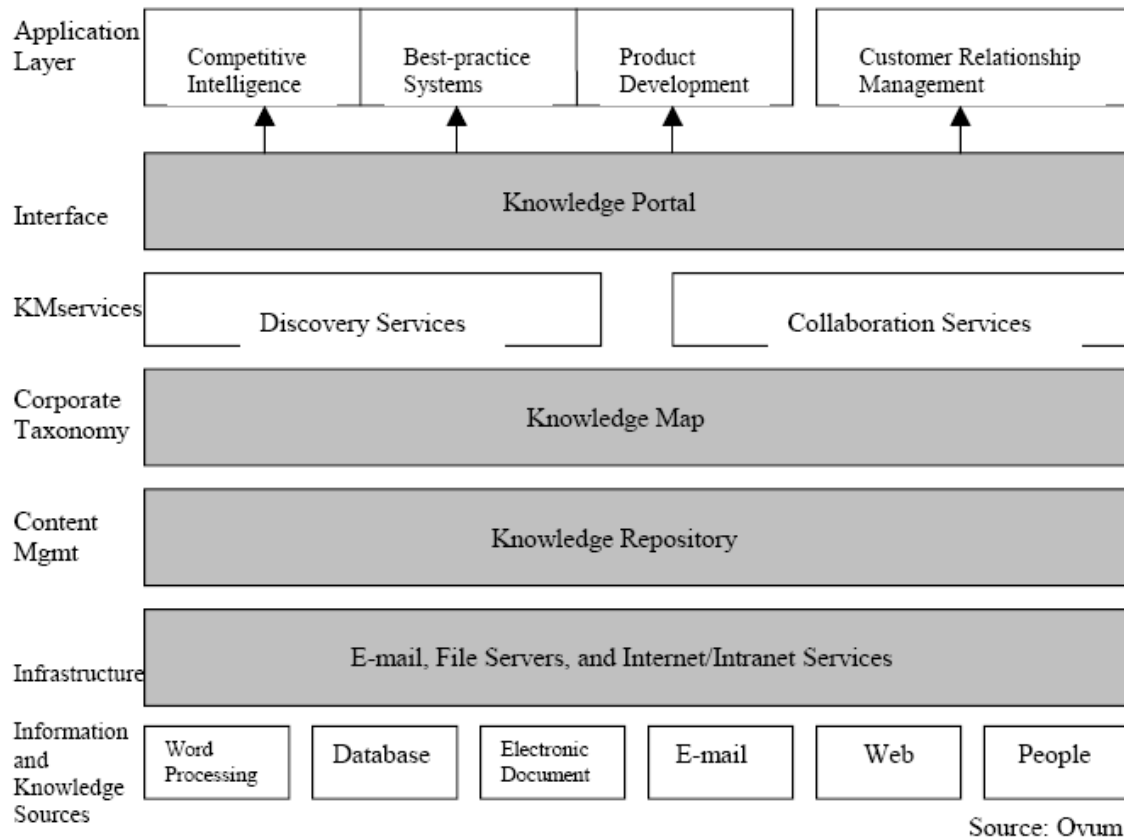
Figure 2.4: Sample Knowledge Management Architecture (Lawton: 2001)

Goals

1. Technology Architecture to support knowledge management is planned and systematically implemented in line with the knowledge management program.

Commitment to perform

1. The organization has a defined plan and implementation strategy for the Technology Architecture needed to support the knowledge management initiatives. The plan specifies the following:

   o An outline of the specific requirements, in line with the knowledge management initiatives and maturity in the organization. This will include the characteristics of the organization in terms of the size, geographic locations, and other dimensions.

o The technology products and solutions that will be used in supporting knowledge management implementation. Choices will be outlined, and selection will be made of the appropriate technologies. Where needed, the organization will commit resources to develop or extend solutions to meet the needs of the knowledge management initiative.

o A timeline and cost associated with the implementation of the Technology Architecture.

2. A defined technology group has accountability for planning and implementation of the technology architecture and provides periodic updates to senior management.

Ability to perform

1. A defined technology group is responsible for planning, coordinating and implementing the Technology Architecture. This group will work with senior management to understand the needs for supporting the knowledge management initiatives in the organization. This group will evaluate and recommend the technology alternative based on matching the available products and solutions in the marketplace. They may work with other groups to create or modify existing solutions to meet the needs of the organization.

2. Adequate resources and funding is available for creating the Technology Architecture.

3. The technology group is trained adequately in basic concepts of knowledge management to understand the requirements of technology to support the initiative.

Activities performed

1. The technology group works with senior management and other groups to identify the needs for the Technology Architecture. The following provides a representative set of areas that the team may focus on:

o Storage needs to ensure the correct technical infrastructure is created for storing the knowledge artifacts.

o Requirements for conversion of knowledge states, between tacit and explicit states.

o Requirements for search and retrieval for different types of knowledge resources. Examples of knowledge resources include artifacts, expertise, systems, projects, and processes.

o Requirements to support the capture and flow of knowledge among collaborative teams working together. Requirements associated with support workgroup communication to support informal conversations to promote the flow of tacit knowledge.

- o Specific tools and products that can store different aspects of knowledge that are created in the system, including the classification scheme associated with each knowledge resource. Standards that will be followed in the classification of knowledge resources will be decided.

2. The technology group will define the architectural requirements or quality attributes for the knowledge management system. Quality attributes may include requirements associated with availability, performance, security needs, usability, modifiability, and testability of the system.

3. The technology group will identify and select a set of alternate technologies and development needs that satisfy the needs, with a cost and timeline associated with each. They will create a complete integrated view and provide the infrastructure needed. Examples of approaches include the following:

   - o Technology for storage of artifacts in terms of a document management or database management.

   - o Use of appropriate internet technologies for wide-spread access of knowledge using a specific architecture for delivery of knowledge.

   - o Use of text analysis, where appropriate, to automate certain aspects of classification of the artifact based on the text content. Usage of similarity analysis with assistance from experts for classification.

   - o Use of specific retrieval techniques to ensure a high degree of precision and recall when people require information from the knowledge storage. Some of this will be based on the classification, while other techniques will use text mining to look inside an artifact. Automatic routing of new artifacts based on content, and need (subscription) to the content.

   - o Use of text retrieval and data mining to get artifacts that bear extensive correlation to ones of interest.

4. The plan will be reviewed with senior management and affected groups. This will include the knowledge expert groups, the knowledge management process group, the knowledge representation group, and project teams that are involved in defining the needs.

   - o The review will include a verification of whether the organization and project level requirements are being met with the technology implementation.

   - o The technology group can use knowledge experts to train systems for greater accuracy in retrieval as well as to assess the results of the implementation of search and retrieval techniques, if such an approach is used to implement the needs of the knowledge management system.

   - o The knowledge representation group will be involved in defining and verifying the classification scheme for knowledge artifacts.

o The knowledge management process group will work with the technology group to ensure that the process implementation has technology support.

o In addition, review of the support for people practices and communities of practice using the technology architecture will be verified.

5. The technology group will execute the plan, and report progress in terms of activities completed, costs, progress, and timeline for implementing the technology architecture. Once the baseline technology architecture is implemented, they will conduct periodic checks to identify gaps in the infrastructure with the changing knowledge management needs. These will be implemented as an ongoing investment in technologies with the changes in the knowledge management program in the organization.

Measurement and analysis

1. Measurements are made to understand the status of the technology architecture. Examples of measurement include costs, progress, schedule, and activities conducted in the planning and implementation of the technology architecture.

Verifying implementation

1. The activities associated with Technology Architecture are reviewed with senior management on a periodic basis.

Organization Knowledge Ontology

Rationale

The purpose of the organization knowledge ontology key process area is to ensure that there is a standard taxonomy that is used for the classification of knowledge stored in the organization. The goal is to develop a meaningful vocabulary for knowledge in the organization and to socialize this classification scheme within the organization. The knowledge representation group will work with knowledge experts to ensure that the knowledge classification is fully and accurately captured and represented in the ontology for the organization. This key process area emphasizes the role of standardization in knowledge classification across the organization, which is essential for the transfer and movement of knowledge across the organization. Knowledge management requires standards in knowledge classification to ensure that scalability is attained in terms of knowledge retrieval. This important organizational commitment requires multiple groups to work together to create a specific ontology that is representative of the terms and usage of terms in the organization. The knowledge classification scheme must have adequate depth (to ensure fine classification) and breadth (to ensure coverage). The thinking process of the knowledge representation will come primarily from the organization's map of its core business. Organizations can chose to adopt various forms of formal knowledge representation that can be used as the foundation for the classification scheme.

Goals

1. Knowledge classification standards are defined for the organization.

2. Appropriate knowledge resources are classified as per this standard in the storage mechanism defined in the organization

Commitment to perform

1. The organization follows a policy for classification of knowledge resources for the organization. The policy specifies the following:

   o An approach for the creation and periodic verification of the knowledge ontology for the organization.

   o A complete and documented ontology of knowledge.

2. The knowledge ontology group is assigned the responsibility for planning and implementation of the organization knowledge ontology and is responsible for reviewing progress with senior management.

Ability to perform

1. A knowledge ontology group is assigned the responsibility for coordinating, creating, and maintaining the knowledge ontology. The knowledge ontology group is trained adequately in basic areas of information retrieval.

2. The knowledge ontology group will work with knowledge experts to define the knowledge representation standards that will be followed in the organization. The knowledge ontology group will define the method of storing the knowledge classification with the knowledge artifacts. The agreed upon ontology will be used in the classification of the documents. The knowledge ontology group may use automation techniques for the classification of new artifacts based.

3. Adequate resources and funding is available for creating and maintaining the knowledge representation.

Activities performed

1. The knowledge ontology group works with knowledge experts and other groups to create the ontology definition for the organization. The knowledge ontology group will define standard terms used in the organization, and create a standard documentation associated with the terms and representation in the organization. The representation group may define a thesaurus for usage within the organization in order to ensure that terminology and interpretation is as per the definition and scope of the thesaurus.

2. The representation group will be responsible for conducting periodic training within the organization to ensure that the project teams understand the

classification of knowledge and its application to classify knowledge resources. In addition, they will present the results of effective search techniques for retrieval of knowledge artifacts.

3. The knowledge ontology group will conduct periodic meetings with the knowledge experts to ensure that the classification scheme used meets the requirements of the search and retrieval goals. They will use defined information retrieval techniques to ensure that retrieval efficiency can be systematically measured. The knowledge ontology group will conduct periodic meetings with the knowledge expert teams to ensure that the representation scheme is changed with the addition of new terms, and new artifacts.

4. The knowledge experts may use formal techniques of text mining to validate the efficiency of the classification scheme. The knowledge experts may use tools in information retrieval to validate the efficiency of the classification scheme.

5. The knowledge management representation and knowledge expert groups will conduct periodic audits to ensure that the resources are being classified as per the defined organization ontology. This will ensure that the knowledge artifacts that are being stored in the storage scheme conform to the representation and classification standards. The knowledge ontology group will participate with project teams at knowledge capture stage to ensure that the knowledge captured has been classified in line with the ontology defined for the organization. In addition, they will participate to train project teams in the knowledge fulfillment process, where needed, to ensure that the available and relevant knowledge resources are made available to the project teams.

6. Senior management will participate to conduct periodic reviews of the knowledge representation of the organization and ensure that any conflicts among knowledge experts are resolved.

Measurement and analysis

1. Measurements are made to understand the status of the knowledge representation. Examples of measurement include size and span of the ontology, changes made to the ontology over time, usage of the ontology in terms of classification and retrieval.

Verifying implementation

1. The activities of knowledge representation are reviewed with senior management on a periodic basis.

People Practices

Rationale

The purpose of the people practices key process area is to ensure that there is an organization wide commitment to implement appropriate people practices to support the knowledge management practices. The tasks associated with people practices will be training, rewards, and recognition schemes associated with fostering an environment in the organization that is conducive for an effective knowledge management program. Training will include awareness training, and specialist training in different aspects of knowledge management. Rewards and recognition schemes will be used to ensure that the practices associated with knowledge management have a link to the performance management of people in the organization. This key process area emphasizes the role of people in knowledge management. The basic cultural building blocks need to be in place for the effective implementation of knowledge management. Knowledge management requires an alignment of people practices to ensure a successful implementation within an organization. Firstly, people must be made aware that knowledge management related activities are part of their job. This must then translate into specific measures so that when the performance of the person is assessed, knowledge management related activities appear as part of the appraisal process. In addition, specific training must be imparted to ensure that relevant skills are provided to the people in order to perform the job. People practices addresses specific initiatives that the organization needs to take to ensure that all the process and technology oriented parts of knowledge management are supported within the organization by aligning specific schemes associated with people practices. Some of this will include the need for people to develop skills in communication to ensure that they can communicate the learnt knowledge. In other cases, the people practices must encourage the sharing process by providing incentives for sharing knowledge.

Goals

1. People practices associated to align to the knowledge management program are defined and followed in the organization.

2. Information on people working on different aspects of a project are stored in a controlled manner.

Commitment to perform

1. The organization follows a policy for people practices for the organization. The policy specifies the following:

   o Training needs for people to ensure that they are made aware of the benefits and their role in the knowledge management initiative.

   o Performance management practices that reflect rewards and recognition for people with tasks associated with knowledge management.

- o Specific information to be stored at the end of a project associated with the role performed by team members.

2. Senior management assigns resources to ensure that the people practices are supportive of the knowledge management practices. Senior management will review the culture of the organization as is manifested by the alignment to the knowledge management program and periodically modify the people policy to ensure that appropriate rewards and training are included to foster a strong alignment to the program.

Ability to perform

1. There is a defined team assigned by senior management to create the policies for people practices within the organization.

2. The policy makers for people practices have complete understanding of the goals and business benefits of knowledge management practices in the organization. They are aware of and trained in cultural factors that need to be defined to promote an effective knowledge management program. They have an understanding of specific people practices that need to be addressed to ensure alignment to knowledge management practices.

3. Project managers and tea members are trained in usage of appropriate forms for storing information on the role performed by individuals in the project.

Activities performed

1. People practices are defined in detail and integrated into the policies within the organization. These policies are periodically reviewed to ensure that these are effective in line with the knowledge management program.

- o Specific roles will be defined in the organization. These roles will be used to determine the bounds of activities performed by individuals working on projects. The organization will also define a consistent mechanism for determining the level of expertise of an individual, based on an aggregation of roles and activities performed by the individual. Examples of such a mechanism are completion of a set of pre-defined roles or completion of a certain set of activities in a role to be designated at a certain level of expertise.

- o Policies will address the needs and implementation of knowledge awareness training within the organization.

- o Specific rewards and recognition schemes will be integrated into the performance management for superior involvement in knowledge management. Examples could include active participation in knowledge management initiatives such as proactive knowledge need determination, knowledge capture accuracy, participation in knowledge dissemination, knowledge enrichment and so on. Rewards could be defined for different aspects of knowledge management implementation that have the highest

business benefits. Examples include the team with the most effective knowledge capture, or dissemination, the most effective set of artifacts and the team involves in creating, capturing, and enriching the artifacts, the team and people with the most successful implementation of knowledge practices, an annuity award for the artifacts that are extensively used, knowledge expert groups that provide the highest business value.

- o Training will be conducted to emphasize on communication skills, and the need for abstraction. Differences of types of knowledge (tacit versus external) and techniques for extracting tacit knowledge will be provided to people.

2. The organization implements the training and rewards as per the policies stated in people practices. This includes the training programs and the rewards scheme that are part of the people practices defined in the organization.

3. Senior management will conduct periodic reviews of the people practices of the organization to ensure that they are in line with the goals of the knowledge management practices. Where needed, the people policy will be changed to promote alignment to the knowledge management program of the organization.

Measurement and analysis

1. Measurements are made to understand the implementation of the people practices in the organization. Examples of measurement include number of people trained, number of people at different levels of expertise over time, number of training conducted per reporting period, specific rewards given out for adherence to knowledge management practices.

Verifying implementation

1. Senior management reviews people practices on a periodic basis.

Integrated Knowledge Management

Rationale

The purpose of this key area is to integrate the knowledge management activities that are defined at the organization level into project-centric knowledge processes and permit an organization-wide view of knowledge management. The basic practices for knowledge need planning, knowledge capture, fulfillment and storage for a project have been described in Level 2. Level 3 processes provide organization-centric commitment as follows:

- Technology Architecture ensures that projects use the organization directive associated with tools and technologies to support the knowledge management program.

- Knowledge Enrichment integrates the use of knowledge experts in projects use and ensures that the associated organization-defined processes for enrichment of captured artifacts, and derive the benefits of effective knowledge in dissemination.

- Knowledge Representation ensures that the organization-defined classification scheme for knowledge resources is followed at the project level.

- People Practices ensures that organization policies are aligned to foster a knowledge-centric culture in projects.

Integrated knowledge management attempts to integrate organization-centric processes at the project level to provide an integrated framework for knowledge management. At level 2, it creates a threading of processes at the project level (knowledge capture, knowledge dissemination, fulfillment and storage) to be consistently used across the organization. It provides a framework to thread organization process focus and definition to the project, and ensures that the project has a systematic method of approaching knowledge management practices derived from organization level processes. This provides an organization-wide view of the knowledge needs for the organization and can be used to determine areas of focus for knowledge development.

Goals

1. The activities associated with knowledge management in the project are fully integrated into the underlying process framework for organization-centric knowledge processes. Projects follow a defined plan for knowledge management that is tailored from the organization-defined process.

2. There is an organization-wide and aggregated view of demands, growth, and fulfillment of knowledge in the organization, based on activities carried out in projects.

Commitment to perform

1. The knowledge management process group provides an integrated view of the organization-defined processes as it relates to a specific implementation in a project. The project follows a written organizational policy requiring that the knowledge management activities in a software project be planned and managed in line with the organization's standard knowledge management process. This policy typically specifies that each project documents the project's defined knowledge management process by tailoring the organization's standard knowledge management process. The project's deviations from the organization's standard knowledge management process are documented and approved. Each project performs its knowledge management activities in accordance with the project's defined knowledge management process. Each project collects and stores appropriate project measurement data in the organization's knowledge management process database.

2. The organization reviews knowledge needs, fulfillment, capture, and storage associated with all projects in the organization. The organization will divert resources to areas where the impact of knowledge management processes has the greatest opportunity for economic impact.

Ability to perform

1. Adequate resources and funding are provided for managing the knowledge management activities in a software project using the project's defined knowledge management process.

2. The individuals responsible for developing the project's defined knowledge management process receive required training in how to tailor the organization's standard knowledge management process and use the related process assets. Examples of training include using the knowledge process database, using the organization's standard knowledge management process, and using the guidelines and criteria for tailoring the organization's standard knowledge management process to meet the needs of the software project.

3. Project managers and project teams receive required training in managing aspects of knowledge management as it applies to the software project. Examples of training include:

   o Leveraging expertise from knowledge experts at various stages of the project.

   o Understanding the ontology used to classify knowledge resources.

   o Methods and procedures for knowledge capture, dissemination, capture, assessment as it relates to explicit and tacit knowledge.

   o Usage of organization-defined tools and technology for different aspects of knowledge management.

   o Implementing appropriate people practices to foster the appropriate culture to support the knowledge management initiative.

Activities performed

1. The organization's standard knowledge management process is tailored according to a documented procedure to develop the knowledge management process for a project. This procedure typically specifies that the organization knowledge management process can be tailored as per specific guidelines. The description of the project's defined knowledge management process is documented. The knowledge management process group reviews tailoring of the organization's standard knowledge management process for the project.

2. Knowledge management in a software project is performed in accordance with the project's defined knowledge management process. The project's defined knowledge management process typically specifies:

- o Usage of specific tools and technologies in the project, in line with the defined technology architecture.

- o Timing for capture of knowledge in the project, and involvement of appropriate teams in the process of capture and classification.

- o Nature of participation of knowledge experts in the project for enrichment and knowledge dissemination.

- o Specific rewards in line with people practices for the project team members who have participated in the knowledge related activities.

- o Classification nuances as specified by the knowledge ontology.

3. The knowledge management practices across projects are reviewed by different groups as follows:

    - o The knowledge ontology group reviews the classification scheme that is in use vis-à-vis the defined organizational ontology. Changes are made to the organizational ontology, where relevant, to reflect the interpretation and usage of the classification scheme. The usage of retrieval of knowledge resources will be used to determine if there are weaknesses in the knowledge ontology or its implementation and these will be addressed.

    - o Aggregated knowledge needs will be reviewed to identify areas of intense knowledge needs and organization resources will be aligned to meet the requirements in these areas. In addition, areas of knowledge needs that have minimal fulfillment will be identified as areas that require specific attention. Knowledge expertise in the organization will be matched up to the aggregated knowledge needs of the organization.

    - o The knowledge management process group reviews knowledge processes of knowledge need, capture, storage and dissemination on an aggregate basis for the organization to determine changes to the baseline knowledge management process for the organization. Changes may be made to the tailoring guidelines for the project related processes.

    - o The technology group identifies the usage of tools and technologies for knowledge management and addresses any gaps in usage by making modifications to the technology architecture.

    - o Senior management will review the activities performed by different groups vis-à-vis the knowledge management practices followed by a project to determine appropriate alignment of organization resources in areas of maximum business need. Examples include review of knowledge enrichment to determine effectiveness, analysis of similar projects to determine reuse of knowledge, effectiveness of participation of knowledge experts.

Measurement and analysis

1. Measurements are made to understand the status of the integrated knowledge management. Examples of measurement include costs, progress, schedule, and activities conducted in the planning and implementation of the knowledge management for the project.

Verifying implementation

1. The activities of integrated knowledge management are reviewed with senior management on a periodic basis.

Level 4 Key Process Areas

Organization Communities of Practice

Rationale

The purpose of organization communities of practice (CoP) is to integrate knowledge communities into the organization's knowledge management initiative. Communities of Practice forms the mechanism for professionals to come together on topics of mutual interest, and work together in problem solving, and sharing of knowledge amongst one another. CoPs provide a greater degree of focus for collaborative dialog and sharing by knowledge experts who tend to lead communities based on mutual interest and respect. With a structured framework, and using the technology architecture, communities of practice form the basic mechanism for superior knowledge enrichment that is motivated by the members of the community. This requires focus to understand and create an environment to foster the members of the community, so that resources can be partly spent on knowledge management practices associated with the community. The maturity of a community can be assessed in formal terms based on the nature of maturity of the community as shown in Figure 2.6 (Gongla and Rizzuto: 2001). This approach of having a formal process approach, which offers the potential for direct benefits, with appropriate technology support ensure that the critical success dimensions related to organization, cognition, economics and technology are met (Scarso et al: 2009, 2008).

	Potential	Building	Engaged	Active	Adaptive
Definition	A community is forming.	The community defines itself and formalizes its operating principles.	The community executes and improves its processes.	The community understands and demonstrates benefits from knowledge management and the collective work of the community.	The community and its supporting organization(s) are using knowledge for competitive advantage.

Figure 2.6: Evolution of maturity of communities (Gongla and Rizzuto: 2001)

Goals

1. The organization has a formal definition and implementation for the Communities of Practice to participate in the knowledge management program in the organization.

Commitment to perform

1. The organization creates standard guidelines for creating and maturing communities of practice in the organization. The organization will use a standard definition to assess the maturity of its CoP initiative. The following provides a staged framework for assessing the maturity of the CoP (Gongla and Rizzuto: 2001).

   o Potential: The fundamental function is connection centric with an aim to get individuals to find one another and create a community. At this stage, potential community members are located. Organization tasks are facilitative in getting a community formed. Technologies may include e-mail, chat rooms, lists, phone calls, teleconferences, on-line forums and directories.

   o Building: The goal is to set memory and context of the community. Here, the goal is to start having community members interact to learn about each other and start sharing experience. Common vocabulary, an understanding of roles, and initial story-telling takes place at this stage. The organization recognizes the community. Themes regarding the integration into the knowledge management initiative take place at this stage. Technologies could include initial classification and categorization schema tools, document and library management systems and tools to support collaborative work.

   o Engaged: At this stage, the goal is to promote access and foster learning. There is greater trust among community members, and committee members are able to provide systematic commitment. Knowledge sharing techniques are discussed with an effort to uncover tacit knowledge. Members actively search for and contribute material to build the community knowledge. The organization interacts with the community by starting to integrate them into the knowledge management program. New members are actively solicited and socialized into the community. The community starts to develop greater knowledge dissemination strategies. The goals of the community are visited to ensure that community definition and scope is in line with the current maturity. Technologies include portals, expert and community "yellow pages" or locators, and feedback tools.

   o Active: The goal is to foster greater collaborative problem solving in a goal-centric manner, and aligned to the project and organization-centric knowledge management initiative. Individuals engage other community members to solve problems and do "real work". The community connects to and interacts with other communities. The organization actively supports and measures community work. The organization begins to rely on the community's knowledge to contribute to business value. Technologies include electronic

  meetings, collaboration tools, such as for issue-based discussion, analytical and decision-making tools.

  o Adaptive: The goal is to support innovation and knowledge generation. The community changes its environment through creation of new knowledge. Members working together advance the knowledge, and even the definition, of their field. The community sponsors new communities. The organization uses the community to develop new capabilities and to respond to and influence the business setting. Technology includes integration with the technologies of external organizations and technology transfer.

2. Senior management fosters development of communities of practice in the organization.

Ability to perform

1. There is a well-defined and published set of communities of practice in the organization. The organization publishes and publicizes the existence of the communities of practice in the organization. The communities of practice use the technology architecture to provide an appropriate forum for collaborative functioning. The work done by the communities of practice is published in designated forums that are sharable and accessible to other members in the organization. These could include work-groups, chat sessions, bulletin-boards, the intranet, formal knowledge databases, portals, and other mechanisms for storage and publication of the knowledge.

2. Adequate resources and funding is available for permitting the members to work in activities associated with the community of practice. This could include mutual discussions, research and discussions of the domain that the community works in, knowledge dissemination sessions, enrichment sessions and collaborative work.

3. Senior management spends time to socialize the maturity phases of a community to establish a consistent method of calibrating each community.

4. Each community of practice will create a broad charter to define its goals. This will include goals associated with knowledge enrichment, and dissemination. There will also be a stated periodic formal meeting to review the progress of the community of practice to meet the goals set forth. The communities of practice have an understanding of their context and contribution as it relates to the knowledge management program within the organization.

Activities performed

1. Communities of practice will set goals at periodic intervals for themselves. The area that the community would like to focus on will be defined. This is widely made known to the organization, by management communications. These areas will be formally mapped on to the organization-defined ontology to permit access

to multiple communities. Technology architecture that will be used by the community of practice for their own work will be defined in line with the needs and stylistic preference of the community.

2. Communities will integrate into the knowledge activities taking place at the project domain. The community can define the level of participation in the knowledge management initiative by defining its specific scope and domain of interest. Examples could include participation in specific knowledge needs that arise in the organization. Such needs could become the natural area of interest in the community.

3. Communities will be made aware of the knowledge activities taking place at the organization level including areas of knowledge enrichment. An example of this is where the community builds upon the knowledge enrichment formally conducted by the knowledge experts. Much of the knowledge enrichment will happen at the community of practice, while some formal sessions with projects may take place with knowledge expert intervention. The behavior change is that the knowledge captured in the organization is integrated into the community as a knowledge culture within the organization.

4. Communities of practice will conduct periodic knowledge dissemination sessions to provide information on the areas of focus and any specific achievements. Communities of practice will report the growth and activity progress of their community. This can include:

   o People who have joined and left their community.

   o Levels of knowledge centric activity including new competencies that is in pursuit by the community. Areas of knowledge that the community is working on.

   o Participation in defining knowledge needs for a project, knowledge fulfillment, knowledge capture and storage for projects.

   o Degree of tacit knowledge that is being captured in the community, including transformation of knowledge between tacit and explicit states.

5. Senior management will participate to conduct periodic reviews with the communities of practice to assess the maturity levels in line with a predefined model for CoPs.

Measurement and analysis

1. Measurements are made to understand the status of the communities of practice. Examples of measurement include current maturity of the community, time taken to reach each maturity level, number of sessions used for knowledge dissemination, level of activity in the community of practice.

Verifying implementation

1. The activities of communities of practice are reviewed with senior management on a periodic basis.

Quantitative Knowledge Management

Rationale

The purpose of this key area is to establish a set of quantitative measures for assessing and the performance of the knowledge management program and using these to make changes in the knowledge management program. The organization collects quantitative knowledge management performance data and uses this to characterize the effectiveness of the knowledge management practices within the organization. This key process area emphasizes the need for ensuring that the knowledge management practices have a quantitative framework for measuring the benefits and improvements. Table 2.1 provides some measures that can be applicable to measuring different aspects of a knowledge management program (Arora: 2002). These can be considered proxy measurements that can be expected to have an economic impact on the core business of the GDC as stated in the table.

Table 2.1: Quantitative Measurement

Proxy Measurement	Expected Impact
Amount of codification of available knowledge resources.	Opportunity for fulfilling knowledge needs with relevant knowledge artifacts, expertise and communities of practice.
Popularity and importance of the codified repository.	Wide-spread usage of repository may provoke teams to have greater focus on knowledge need definition for projects, assist in improving the alignment and relevance of the knowledge capture process.
Repeat usage of the repository items in terms of hits, feedbacks.	Provides an opportunity to determine greater areas of knowledge interest in terms of knowledge needs, fulfillment and can align knowledge experts and creation of communities in these areas.
Updates in the existing repository to keep it current.	Ensure that meaningful knowledge resources get applied in the knowledge management process, eliminating inefficiencies of working with inaccurate knowledge.
Level of interactions, discussions and collaborations among the employees on important identified subjects.	Demonstrates the current state of culture within the projects and in organizational terms.
Brainstorming, recommendations, get-togethers, knowledge sharing sessions organized by the communities within their meetings and also externally.	Expectation is a correlation between this and the impact on knowledge fulfillment and dissemination as it happens with knowledge experts and communities to project teams.
Suggestions made and experiments conducted by the community.	Belief is greater knowledge aggregation in the community that can then be used by the business.
New products/practices introduced – it may reflect the effectiveness of the collaboration through communities and databases.	Expectation is greater impact on the areas of knowledge enrichment and reuse of existing knowledge.

Problems solved, benefits obtained by sharing best practices through communities and databases.	Possibility of greater impact in knowledge fulfillment.
Measure of knowledge assets and intellectual capital.	Provides an aggregated and consolidated view of the current knowledge level in the organization.

Quantitative knowledge management ensures that there is a commitment for formal measurement and quantification of the critical measures to ensure that the benefits of the practices are being derived by the organization. This is a critical aspect to ensure continued commitment on behalf of the organization. Measures could be a combination of leading-edge indicators and business-centric measures in line with the business of the GDC. Business-centric measures could include return on investment (investment being the time, effort, and costs associated with the knowledge management activities), improved productivity of teams, greater speed of delivery, reduced defects of produced software, and reduced time to market for solutions.

Goals

1. Quantitative measurement for the knowledge management initiative is planned. This plan is used to establish a systematic, periodic and consistent measurement program for knowledge management activities in the organization.

2. Quantitative measurement of the knowledge management initiative is used to take appropriate preventive and corrective steps at the project and organization level.

Commitment to perform

1. The organization commits to create a plan associated with the measurement of the knowledge management program. Relevant groups participate in creating and adopting the plan. Measurements are taken at the organization and project-level activities in line with the defined plan. The organization follows a standard for analyzing the process capability of the organization's standard knowledge management process. This typically specifies that:

   o The measurements of process performance across projects are analyzed to establish and maintain a process capability baseline for the organization's standard knowledge management process.

   o The process capability baseline includes the description of the organization's standard knowledge management process, the standard definitions of the measurements, and the expected range of values for the measurements.

   o The process capability baseline for the organization's standard knowledge management process is used by the software projects in establishing their knowledge management process performance goals.

2. The organization has standard norms for measuring the effectiveness of the knowledge management initiatives in the organization.

Ability to perform

1. The knowledge management process group is responsible for coordinating the quantitative knowledge management activities for the organization. The members of the knowledge management groups receive orientation on the goals and value of quantitative process management. The individuals responsible for implementing or supporting quantitative process management receive required training to perform these activities.

2. Adequate resources and funding are provided for the activities associated with quantitative measurement of knowledge management activities. An organization-wide measurement program exists, which includes the definition of the organization-wide measurements, the collection procedures of the organization's measurement data, the analysis to be carried out, and quantitative measurement goals for the organization. Tools to support quantitative knowledge management are made available.

Activities performed

1. The knowledge management process group develops the plan for quantitative knowledge management for the organization. This will include measurement associated with organization-centric knowledge management processes. Examples of measurement include:

   o Community–centric measurements to determine effectiveness of communities of practice. This could include number and size of communities created in different time periods, contribution of communities to a project's knowledge needs, innovative ideas generated by communities.

   o Total number of unfulfilled knowledge needs over a period of time. This can be correlated to the number of knowledge experts and communities working in related areas.

   o Knowledge enrichment activities taking place with experts and communities to reflect new knowledge getting created in the organization. This can be correlated to knowledge needs, both current and forecasted for the organization.

   o Expected impact of knowledge management related activities in the economic parameters of a project at different levels of engagement in the knowledge management program. Economic parameters for a project include effort, schedule, cost, and number of defects in the software.

   o Expected efficacy of knowledge retrieval based on the defined ontology for the knowledge storage vis-à-vis actual retrieval.

2. The project's quantitative knowledge management activities are performed in accordance with the project's quantitative knowledge management plan. Included

in the plan are standard measures for different knowledge-centric activities in the project. Examples of measures include:

- o Expected fulfillment of knowledge needs in a project that belongs to a specific domain vis-à-vis actual fulfillment.

- o Expected number of artifacts and knowledge resources to be captured and stored as a consequence of completion of a project vis-à-vis actual numbers.

- o Planned versus actual effort in knowledge related activities in the project.

3. The strategy for the data collection and the quantitative analyses to be performed are determined based on the project's defined knowledge management process. The strategy will include:

- o Data collection and establishment of standard bands of performance for the knowledge management practices.

- o Specific analysis that is used on the data that is collected. This may include a statistical quality control tools to understand variation of performance.

- o Improvements will be suggested and tracked until closure.

4. The knowledge management process group reports quantitative measurement to senior management against the expected baseline on a periodic basis.

Measurement and analysis

1. Measurements are made to understand the status of the quantitative knowledge management. Examples of measurement include cost of quantitative knowledge management activities.

Verifying implementation

1. The activities of quantitative knowledge management are reviewed with senior management on a periodic basis.

External Knowledge Integration

Rationale

The purpose of external knowledge integration is to ensure that the practices of knowledge management can extend beyond the confines of the organization to key external partners. There is a tight relationship among external knowledge, knowledge management scalability, and corporate performance and knowledge management capability could be a critical mediator between external knowledge and corporate performance (Tseng and Wu: 2012). All key external constituents working with the organization get integrated into the knowledge management practices. This will include customers, vendors, and alliance partners. This provides the ability for the organization to extend its capture and dissemination of knowledge across the value chain of the

organization's services or products. Formal practices will be defined for integrating all external constituents into the knowledge management practices of the organization. This key process area emphasizes the need for extending knowledge management practices beyond the boundaries of the organization, and recognizes the benefits of a greater scope of implementation of knowledge management solutions. Knowledge gets created in the continuum of the software business, and an organization is an artificial demarcation that confines knowledge practices within its boundary. Truly knowledge empowered organizations realize this and ensure that their practices can be extended beyond the boundaries of their own organization and participate fully in the value chain of the software creation and implementation process. Therefore, this can extend to

- The customer in terms of initial planning and thing process for converting business needs into applications, and provide knowledge management practices to ensure rapidity and reuse at this stage. The customer, specifically if they are dispersed and use software development from centralized locations to roll out technology and business solutions using knowledge management practices to ensure greater reliability and acceptance of proven practices.

- Key technology partners who are part of the software solutions to ensure that there is consistent learning and improvement is solutions that they offer.

Our current competitive landscape and the trend towards globalization require new forms of organizational structure and interrelationships between different stakeholders (Pena: 2002). In addition to strengthening internal capabilities, corporate managers need to develop partnership skills in an industry environment where interdependencies among organizations emerge naturally (Pena: 2002). An integrated knowledge management approach should integrate internal knowledge management practices with external constituents beyond the boundaries of the organization. Companies are no longer self-sufficient for the creation, development and commercial exploitation of their knowledge base and, consequently, must seek inter-organizational networks in order to succeed in their respective technological fields (Pena: 2002). An integrated knowledge management framework must comprehend both internal and external elements to create, develop, and exploit knowledge as it is shown in Figure 2.7 (Pena: 2002).
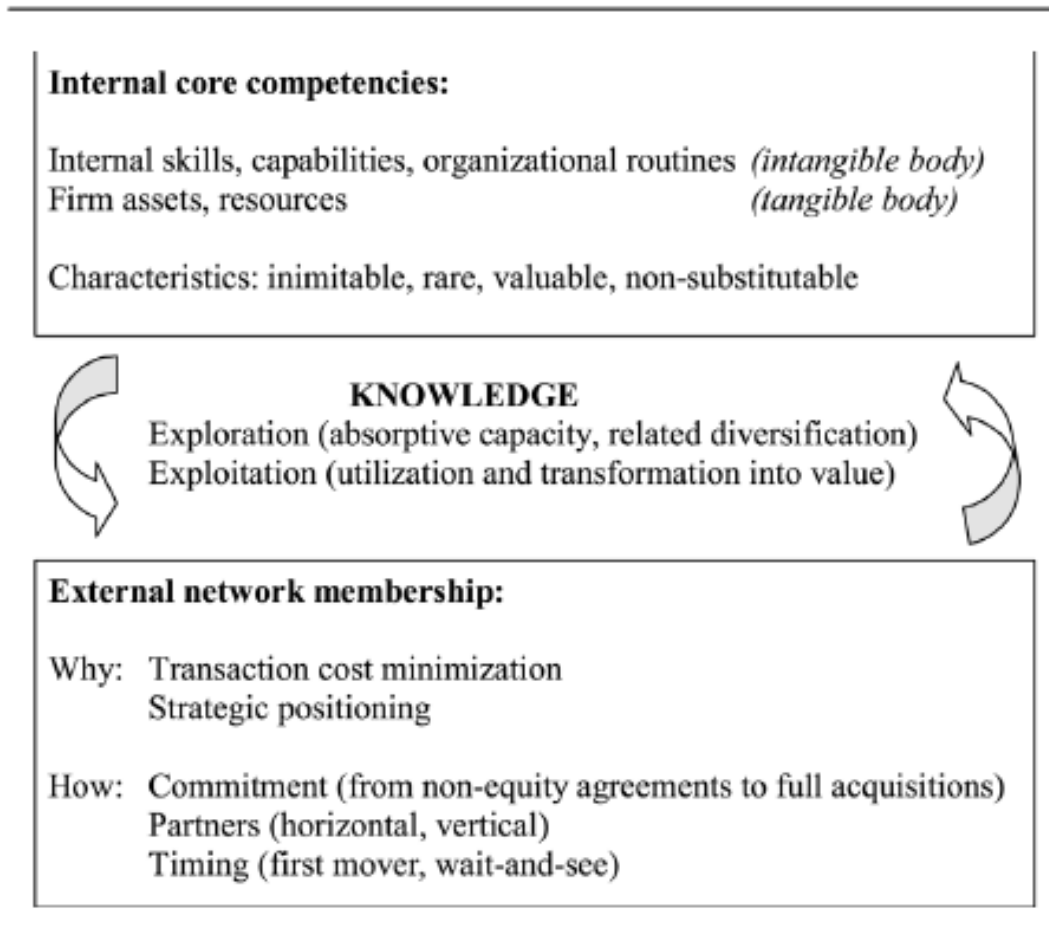
Internal core competencies:

Internal skills, capabilities, organizational routines *(intangible body)*
Firm assets, resources *(tangible body)*

Characteristics: inimitable, rare, valuable, non-substitutable

KNOWLEDGE
Exploration (absorptive capacity, related diversification)
Exploitation (utilization and transformation into value)

External network membership:

Why: Transaction cost minimization
Strategic positioning

How: Commitment (from non-equity agreements to full acquisitions)
Partners (horizontal, vertical)
Timing (first mover, wait-and-see)

Figure 2.7: Integrated knowledge management framework (Pena: 2002)

It is clear that mature organizations will seek to extend their influence across the boundaries of their organization. By providing access to knowledge management practices used in the organization and integrating it to external constituents, organizations reach the next level of maturity in integrating knowledge across the value chain of the services that they deliver to customers. This will also address knowledge interchange using technology to enable greater semantic integration of the ontology use across organizations and permit organizations to gain efficiencies in the interchange process.

Goals

1. External knowledge integration plans are defined for the organization.

2. The organization uses the external knowledge integration plans as one of the contractual terms of working with external constituents including customers and vendors.

Commitment to perform

1. The organization follows a standard policy for external knowledge integration. The policy specifies the following:

   o An approach to identify appropriate partners who need to form part of the knowledge network.

   o An approach for capture, and dissemination of knowledge from and to the external constituent.

   o Integration of the external constituent to technology architecture and knowledge ontology of the organization.

   o Integration into communities of practice and knowledge expert groups in the knowledge enrichment process.

2. Different groups in the organization participate with the knowledge management process group in creating the policy for external knowledge integration. Senior management uses the defined plans to ensure that these are integrated into the working relationships with external constituents.

Ability to perform

1. The knowledge management process group creates a plan for integrating external constituents into the organization's knowledge management practices. This group understands the need for external integration. The assigned group understands the external constituents to be integrated into the knowledge management practices.

2. Senior management identifies specific organizations that need to become part of their knowledge network. They ensure that an appropriate engagement framework exists with external constituents to ensure alignment to the knowledge management practices of the organization.

3. Adequate resources and funding is available for creating the plan for each external constituent's integration into the knowledge management practices of the organization.

Activities performed

1. Senior management will create a set of organizations that need to become part of the knowledge network and work towards establishing a basic framework associated with the setup of such a network.

2. The knowledge management process group will create a documented plan for integrating external constituents who have been identified by senior management into the knowledge management practices of the organization. The plan will include:

- o Basic adherence needs for the external constituents to be integrated into the knowledge management framework.

- o Knowledge fulfillment processes that will be adapted for the external constituent. Participation of knowledge experts from the external organization into the processes of the organization. Likewise, participation of knowledge experts of the organization in specific points in the external organization.

- o Integration (expansion or resolution) of knowledge ontology with the external constituent. Specific mechanics of interchange of the ontology between the organization and the external constituent will be documented and implemented.

- o Participation in relevant communities of practice. There may be communities that have been setup with multiple external constituents working on a set of similar interests. The guidelines for such communities will be established.

- o Documented process for knowledge enrichment and integration of knowledge experts across organizations.

- o Integration of the external constituent into the technology architecture of the organization, with the needed security in terms of access controls and authentication.

- o Checks and controls to ensure compliance with the process.

3. The assigned group will work with the external constituent to implement the plan.

4. Senior management will participate to conduct periodic reviews of the external constituent to ensure consistent compliance with the plan.

Measurement and analysis

1. Measurements are made to understand the status of the knowledge representation. Examples of measurement include knowledge resources that have been used across organization boundaries, participation in knowledge enrichment in a collaborative manner, participation in communities from the external constituent.

Verifying implementation

1. The activities of external knowledge integration are reviewed with senior management on a periodic basis.

Expertise Management

Rationale

The purpose of expertise management is to align the development of capabilities and competencies in people in the organization in line with the knowledge needs and knowledge gaps in the organization. The creation of expertise involves investment in

training and development to create and improve the competence levels in line with the aggregated knowledge needs of the organization. The organization must have a commitment to map out the current areas of competency and determine the gaps in knowledge and have a systematic plan to address the gaps. This could include:

- Allocation of resources in the organization to build expertise in an area through research and development.

- Training of personnel in areas that can build the expertise.

This key process area demonstrates the organization's structured understanding of existing competencies in the organization and commitment to align and develop resources to fulfill gaps in knowledge in the organization.

Goals

1. Aggregated knowledge gaps are identified for the organization.

2. The current level of organizational expertise in identified areas of expertise is formally managed in the organization. Based on the gaps, resources will be deployed to overcome existing gaps and improve the competency levels of the organization.

Commitment to perform

1. The organization follows a standard policy for mapping the expertise in the organization. The policy specifies the following:

   o An approach to identify the areas of expertise and competency in the organization.

   o Precise vocabulary or taxonomy that forms part of the organization's knowledge ontology will be used to define the mapping of the expertise.

   o Periodic review of aggregated knowledge needs to locate and identify gaps in expertise in the organization.

   o Specific avenues to overcome expertise gaps in the organization. Examples include creation of communities in that area to encourage dialog, allocation of knowledge experts to specifically build expertise in the area, external training to build expertise, and execution of pilot projects to build expertise.

2. Different groups in the organization participate with the knowledge management process group in creating the policy for competency management. Senior management reviews defined policy to ensure that resources in the organization are deployed meaningfully to overcome knowledge gaps.

Ability to perform

1. Different groups are trained in identify gaps in knowledge in the organization. The knowledge ontology group has the ability to map the current expertise of the organization and identify gaps in expertise. The knowledge management process group has the ability to determine gaps by reviewing the knowledge needs, knowledge fulfillment, and knowledge repository.

2. Senior management determines the criteria to prioritize the existing gaps in line with business needs. Adequate resources and funding is available to build expertise in areas where gaps exist in the organization.

Activities performed

1. The knowledge ontology group establishes the organization's expertise map using a defined taxonomy that will be used to map the expertise in the organization. This will be reviewed periodically to ensure that the mapping provides adequate breadth and depth to meet the requirements of the organization.

2. The knowledge management process group reviews knowledge resources and processes in the organization to provide an aggregated view of knowledge fulfillment against knowledge needs in different areas of expertise. This will be mapped against the expertise map to identify gaps in expertise in the organization. The gaps will be prioritized using a set of defined parameters to identify areas that have the highest business relevance.

3. The knowledge management process group will identify specific actions to overcome gaps in expertise. These could include one or more of the following:
   o Training of personnel, including knowledge experts, in identified gaps.
   o Setting up of appropriate communities of practice to foster knowledge development in the stated area.
   o Execution of pilot projects in the gap areas to build expertise.
   o Knowledge dissemination sessions for knowledge buildup.
   o Enabling knowledge flow with external constituents to ensure that the expertise can be built up.

4. The knowledge management process group will work with different groups to facilitate implementation of the designated plan. The group will track specific activities and ensure that the knowledge gained reflects in the expertise map of the organization.

5. Senior management will participate to conduct periodic reviews of the expertise management to ensure consistent compliance with the plan.

Measurement and analysis

1. Measurements are made to identify aggregated gap areas, time period to build expertise in designated gaps, cost and timeline to build competency.

Verifying implementation

1. The activities of expertise management are reviewed with senior management on a periodic basis.

Level 5 Key Process Areas

Effective Knowledge Market

Rationale

The purpose of this area is to create an effective knowledge market within the organization. An effective knowledge market provides a strong basis for transfer and exchange of knowledge in an organization defined by the economic fundamentals of supply and demand. Effective knowledge markets focuses on a culture of knowledge interchange and systematically eliminates inhibiting factors for knowledge flow and movement within the organization. This key process area emphasizes the need for organizations to consistently work on the culture of the organization using a strong economic framework (a market model).

Knowledge tends to be mobile within an organization. One of the characteristics of efficient and meaningful movement is the existence of a market that provides an economic context for the movement process. An attempt to map typical market characteristics such as supply and demand, different types of players, and policies of pricing provides a very good understanding of how knowledge can be exchanged within an organization. In such a system, knowledge can be treated like a physical commodity, with certain value attached to it. There will be buyers and sellers who will negotiate to reach a price for the knowledge. This helps understand the climate that must prevail in businesses to promote knowledge exchange. Understanding that there are knowledge markets and that they operate similarly to other markets represents a strong understanding and alignment of the knowledge management program to fundamental economics. This emphasizes the role of technology as an enabling element. Fundamental is the rewards system (price) that the recipient receives for the effort (similar to manufacturing a goods or service).

Goals

1. A specific model exists to create an efficient knowledge market within the organization.

2. The organization uses this model to constantly review and improve the knowledge culture within the organization.

Commitment to perform

1. The organization creates a model that outlines the behavior patterns that need to be promoted in order to create an efficient knowledge market. The plan includes the following:

   o A definition of the knowledge buyers, brokers, and sellers and their roles in the organization. This will map on to the communities of practice, knowledge experts and project teams.

   o Key elements of knowledge pricing used within the organization. The plan will outline specific ways in which the knowledge pricing will be recognized and implemented. Key elements of knowledge market signals are used to assess the model.

   o Rewards and recognition in line with the market dynamics of knowledge in an organization.

2. Senior management uses the defined model and works to ensure that the organization policies emphasize key behavior patterns to create an efficient knowledge market.

Ability to perform

1. A set of groups creates the efficient knowledge market model for the organization. This group will include senior management, and different members from the different knowledge management groups. The group will create a basic model that reflects the creation of an efficient knowledge market, where there is a clear motivation for the efficient and accurate transfer of knowledge within the organization.

2. Senior management will use the model to modify the policies of the organization to include elements that foster the creation of efficient knowledge markets.

Activities performed

1. The model for enacting the effective knowledge market is created. This includes the following:

   o Mapping of the knowledge buyers, sellers and brokers to existing organizational elements.

   o Definition of expected market inefficiencies and specific management reviews to identify and correct these inefficiencies. This could include incompleteness of information, asymmetry of knowledge, and localness of knowledge (Davenport and Prusak: 1998).

   o Definition and review of formal and informal market signals on a periodic basis in order to align rewards and recognition systems to the highest density of applied knowledge.

- o Review the flow of knowledge at an aggregated level to identify an knowledge market pathologies such as a monopolistic environment, existence of artificial scarcity, and trade barriers (Davenport and Prusak: 1998).

- o Define a review of the organization's roles and responsibilities in line with the knowledge market signals in order to ensure that the leadership team understands and is aligned to a knowledge-centric culture.

2. Senior management reviews the model and aligns the policies within the organization to ensure that they support the model. This could include rewards and recognition for people in the organization that are aligned to the rules of the market model. Alternates could include policies that explicitly promote reuse and sharing explicitly, and "punish" creation of already existing knowledge.

Measurement and analysis

1. Measurements are made to understand the status of the effective knowledge markets. Examples of measurement include areas of highest knowledge exchange, areas of knowledge inefficiencies and scarcity.

Verifying implementation

1. The model and implementation of the effective knowledge market are reviewed with senior management on a periodic basis.

Innovation Management

Rationale

The purpose of innovation management is to identify new knowledge areas in the organization (technologies, tools, methods, processes, business areas) and new innovations and track them into the organization in an orderly manner. Innovation in knowledge improves the performance of the organization (Liao and Chuang: 2006). Innovation requires knowledge sharing and a level of trust in the organization, supported by decentralized functioning, technology and strong executive management support (Aulawi et al: 2008). Innovation requires a mind-set that embraces knowledge as critical to organizations, supported by appropriate technologies and processes (Goh: 2005). Innovation Management involves identifying the areas of innovation that are aligned to the business of the organization selecting innovations, and incorporating these into the organization. Knowledge expert groups, communities, and project teams will track new innovations that can radically change the services that are being offered. Specific groups will pilot out the relevant new areas and use the knowledge management framework for rapid adoption of these innovations into the organization. These groups will be constantly seeking out innovations, external or internal to the organization. The maturity level of the organization will permit rapid adoption of innovation and its associated changes into the organization. Innovation management uses all the practices of knowledge management to ensure rapid adoption of innovation into the organization.

Goals

1. The organization has a formal mechanism to identify areas of innovation desired by the business. Incorporation of new innovation is planned.

2. Appropriate innovation areas are transferred using knowledge management practices across the organization.

Commitment to perform

1. The organization follows a policy for tracking areas of innovation for the organization. Any innovation will be evaluated to ensure that it will provide business benefits to the organization.

2. Senior management sponsors organization activities associated with innovation.

Ability to perform

1. The knowledge management process group is responsible for the organization's innovation management activities. The group works with the organizational elements to coordinate and help explore potential areas for applying new innovation, select and plan for new innovation, acquire, install, and customize the innovation, communicate and coordinate with related research and development activities within the organization and communicate with the innovation suppliers on problems and enhancements.

2. Adequate resources and funding are provided to establish and staff a group responsible for the organization's innovation change management activities. Support exists for collecting and analyzing data needed to evaluate innovation areas. Members of the knowledge management process group responsible for the organization/s innovation change management activities receive required training and orientation to the core business of the organization.

Activities performed

1. The organization develops and maintains a plan for innovation change management. The plan will outline the definition of innovation in the context of its impact to the business. This plan covers the assigned responsibilities and resources required, including staff and tools to manage innovation. This defines the decision-making process for identifying areas of innovation that the organization must focus on, in line with the business objectives. The areas of innovation could be one ore more of the following:

   o New technologies and tools to be incorporated.

   o Process areas that are potential areas for innovation are identified to significantly enhance the software development activity.

o System architecture, abstraction, and design areas that can significantly change the business of software development.

o Automation using tools that can change the software development process.

2. The knowledge management process group responsible for the organization's innovation management works with the software projects in identifying areas of innovation and working with multiple groups to ensure that the innovation can be implemented in the organization using the knowledge management program. This group performs the following:

   o Solicits suggestions for innovation. Identifies available innovation that may be appropriate to the organization and projects' needs. Different groups are solicited to ensure appropriate expertise can be leveraged in the organization.

   o Appropriate effort is applied to identify externally available innovations that meet identified and anticipated needs. Systematic efforts are made to maintain awareness of leading relevant work and trends of innovation. Systematic efforts are made to review the any technologies used in the innovation used externally and to compare these technologies to those used within the organization. Areas where new technologies have been used successfully are identified, and data and documentation of experience with using them are collected and reviewed.

   o Where applicable, a structured decision is made to adopt the new innovation in the organization. The new innovation may be piloted in the organization and a systematic plan for adoption is defined in the organization. This will include multiple groups. Examples of involvement include knowledge experts who may be trained in their relevant area, dissemination of knowledge into appropriate communities, modification to the process framework in the organization to define adoption, changes in the ontology of the organization to establish a new or modified classification scheme, enrichment of existing solutions using the innovation, and integration into the project development process.

3. Software managers and technical staff are kept informed of new innovation on a periodic basis using formal and informal channels of dissemination. As an example, information on new technologies is disseminated as appropriate. Information on innovative solutions already in use in parts of the organization is periodically disseminated to ensure that awareness of the innovation and its associated business benefits is created. Technologies used to support the innovation are socialized in the organization.

Measurement and analysis

1. Measurements are made to understand the status of the innovation management. Examples of measurement include number of innovations identified, timeline for implementing innovation, number of innovations, and business benefits derived from the adoption of innovation in the organization.

Verifying implementation

1. The activities of innovation management are reviewed with senior management on a periodic basis.

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