Management requirements for knowledge management systems in the virtual organisation

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Abstract: In the Virtual Organisation, relationships among employees, managers, customers and suppliers are created and terminated on an irregular schedule. This constant turnover jeopardises the organisation's most valuable asset, its knowledge. Without prudent management, the knowledge created through these relationships will be lost. Effective knowledge management enables organisations to protect themselves from the losses experienced when employees and partners terminate their relationship with the company and also facilitates the proliferation of key ideas across organisational subunits and promotes collaboration among diverse project teams. All stages of knowledge management, from acquisition through cataloging, interpretation, transformation, and distribution can be supported. However, technology alone is not sufficient to achieve the objectives of knowledge management. Management policies must also be used to address participation, auditing, interpretation, dissemination and privacy. This paper presents the CaSIDA model for the design of knowledge management systems, describing the inputs and information flows of each stages of knowledge management.

Keywords: knowledge management; knowledge management systems; organisational learning; virtual organisation; information technology.

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1 Introduction

As the modern organisation evolves into a more virtual and distributed form, relationships among employees, managers, partners, customers and suppliers are created and terminated on a more frequent and irregular schedule. Most successful relationships develop distinct communication behaviours and streamlined interaction protocols. They may acquire new insight about company products and services, logistics, customers, or markets. Engineering and technical partnerships can create specific technological advances related to their projects. But there is generally little incentive or process for individuals to store and disseminate this new knowledge in a systematic way. If the relationship is terminated or the individuals leave the company, the knowledge generally leaves with them. Effective knowledge management enables organisations to protect themselves from the losses experienced when employees and partners terminate their relationship with the company and also facilitates the proliferation of key ideas across organisational subunits and promotes collaboration among diverse project teams.

A systematic knowledge management control process requires that knowledge undergo five stages of manipulation: capture, storage, interpretation, dissemination, and auditing. The objective of this process is to maximise the benefits that organisations receive from the knowledge and practices developed by its employees. For the purposes of this paper, knowledge management is defined as a method to convert the unarticulated ideas of employees into structured information and then transform that information into useful knowledge. This knowledge can then be disseminated to other employees who may benefit from it. Knowledge only produces learning if it affects the range and nature of the behaviours of employees [1] and it is only valuable if it improves the performance of the company. Thus the knowledge must be presented to the right person, at the appropriate time and place, and in the correct format in order to produce learning and measurable benefits to the organisation. This is similar to other definitions of knowledge management, such as that of Vazquez et al. [2] who consider knowledge management to comprise

> "all activities and perspectives required to gain an overview of, deal with, and benefit from the corporation's knowledge assets and their conditions." [2, p.3]

2 Knowledge management systems

Knowledge management systems (KMS) are a class of information system that is designed to organise and direct the flow of information and its conversion to knowledge, usually within a particular organisation or community. This differs significantly from a general information management system (IMS), which typically deals with the analysis of data at a much coarser level of sophistication. As a result, the analytics underlying an effective KMS will be categorically different than those used for an IMS.

The information technologies underlying the development and implementation of KMS are still evolving. Currently, all stages of knowledge management can be supported to some extent by existing technologies; however, there is still significant development in bandwidth, interpretation algorithms, and other aspects that are needed for comprehensive KMS implementation. Several authors [1,3] describe the applicability of

information technology to various stages of the knowledge management process, but they warn that technology can also constrain the human aspects of knowledge management [3,4].

Leveraging the ubiquity of internet technologies by using the organisation's intranet and extranet to house the KMS can increase its use and reduce compatibility challenges. Telleen [5] suggests that the powerful communication potential of intranets and their common use as a knowledge base for company information make intranets a natural platform for knowledge management. As suggested by Rosalski [6], organisations need a universal knowledge management architecture to search for and retrieve information, identify expertise and encourage collaboration.

Technology is a necessary but not sufficient component to achieve the objectives of knowledge management. Management processes must also be used to address issues such as participation, privacy, semantic interpretation, and access. Without appropriate management of employee interaction with a KMS, it cannot achieve the potential for protecting and maximising the value derived from the organisation's valuable knowledge assets.

2.1 Types of knowledge

Chandler [7] describes three major categories of company knowledge: technological, operational, and managerial. Technological knowledge is often the category most associated with knowledge management efforts. It refers to the body of laws or principles that define the workings of the organisation's products and/or services. Advances in technological knowledge can set a company's products apart from its competitors in the market. Operational knowledge refers to the processes through which an organisation creates and delivers its products and services. Operational excellence can result in lower costs, reduced delivery times, better customer service, higher quality, and faster time to market for new products. Managerial knowledge refers to the way the organisation oversees its employees, partners, customers, and the interactions among them. This category of knowledge is often overlooked in the knowledge management process. However, in market economies, all three of these categories of knowledge can establish a company's competitive advantage and create a barrier to entry for competition.

Jacko et al. [8] combine Collins' [9] four quadrants of knowledge types with Lam's [10] two-dimensional typology of knowledge and apply them to intranet-based knowledge systems. According to this conception, knowledge is organised along cognitive and organisational dimensions. The cognitive dimension runs from explicit to tacit. Explicit knowledge is consciously accessible to employees and can be articulated. It is generally represented by codes and symbols. Tacit knowledge is part of a larger process and rarely considered distinctively. It is known through context, and hard to represent outside of particular processes. However, Rosalki [6] reports that 42% of company knowledge is tacit and is vulnerable to loss through employee and partnership termination.

The organisational dimension runs from individual to collective. Individual knowledge generally is used only by a limited number of employees to complete activities that they accomplish alone. Collective knowledge is widely known and is part of activities that are accomplished during employee interactions. The four resulting quadrants are defined in Jacko et al. [8] as:

- embrained knowledge (individual-explicit) is individual, formal, abstract or theoretical knowledge and primarily depends on an employee's cognitive skills and abilities
- encoded knowledge (collective-explicit) consists of knowledge conveyed by signs and symbols that can be used in shared organisational processes
- embodied knowledge (individual-tacit) is individual, practical, action-oriented knowledge and primarily depends on the employee's practical experience
- embedded knowledge (collective-tacit) is the collection of tacit knowledge residing in organisational routines and norms.

Each of these contributes to varying degrees to the productivity of the organisation and should be included in any knowledge management system. However, Lam [10] found that organisations tend to be managed according to the knowledge type(s) that dominate its processes. There are considerable implications for how a KMS needs to be implemented depending on both the dominant knowledge types and the management style of the organisation. Heavily controlled and centralised organisations must control their knowledge differently than a decentralised, entrepreneurial organisation.

2.2 Benefits of knowledge management systems

Levitt and March [11] state that individuals in organisations behave and make decisions based on a process of matching known procedures to recognised situations. A KMS can improve company performance by helping employees identify the set of behaviours that are most relevant to the current situation and selecting the action that will maximise the expected results. Similarly, Weick [12] defines the critical component of learning as generating a new response from the same stimulus. Without effective knowledge dissemination, an employee will continue to apply practiced responses that have had satisfactory results in the past. The KMS can identify suboptimalities in these patterns of behaviour and recommend superior actions. Miner [13] suggests that employees must have targets to drive experimentation and this can lead to adoption of new knowledge. The KMS can support experimentation by providing evidence and justification that a new action will result in superior performance.

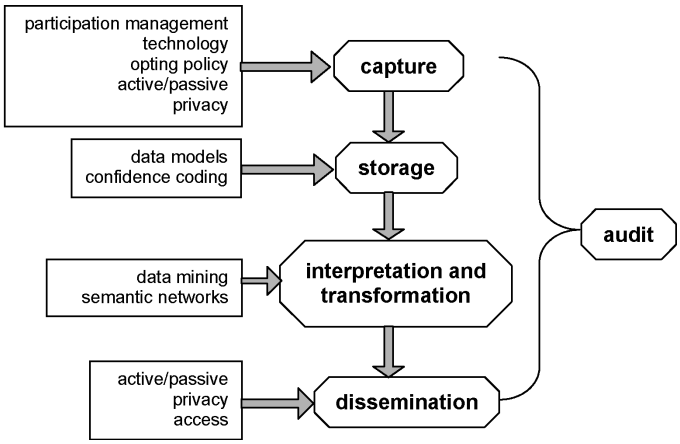
Knowledge management can transform an organisation into one in which learning is a constant and implicit process. This is what Senge [14] refers to as a learning organisation. Learning organisations have feedback mechanisms through which problem solving in one situation can be applied to new situations as they arise [14,15]. KMS provide a pervasive technology that can determine the applicability of solutions to each domain and provide timely notification and guidance. Hence, learning organisations continuously learn and unlearn [16], and re-design themselves through experimentation and feedback.

3 The CaSIDA model

The CaSIDA model includes all five stages of knowledge management (*Ca*pture, *S*torage, *I*nterpretation, *D*issemination and *A*uditing). A diagrammatic illustration is presented in Figure 1 along with the critical considerations that determine the effectiveness of each

stage. The ensuing discussion covers each stage, surveying the key challenges facing effective knowledge management.

Figure 1 Five-stage model of knowledge management with management needs, KMS functions, and management types relevant at each stage



3.1 Capture

Capturing knowledge from employees and partners is critical to the development of a knowledge base. Without effective capture technology and policy, there is no knowledge with which to populate the KMS. Capture systems can be passive or active. Passive systems monitor employee communications and work products to identify and acquire information for inclusion in the knowledge base. Potential channels for examination include work products such as reports, presentation documents, and white papers, and communications from email messages and attachments, telephone monitoring, and meeting agendas and minutes. Filtering the large quantities of information to determine what is sufficiently valuable to include in the KMS and to eliminate redundancies can be problematic with passive systems due to the huge volume of data that is handled by most employees during the course of their work activities. Storage must be available to store an extensive amount of temporary data during the filtration process as well as to store the full knowledge base that is developed. Bandwidth limitations should not jeopardise the productivity of the employee in their normal work activities.

Due to the potential intrusiveness of passive systems when sensitive or personal communications are monitored, the development and communication of privacy and participation policies is critical. Employees are generally sensitive to two issues regarding their privacy in the workplace. When personal documents or communications may be monitored by the system, care must be taken to insure that no recording or human contact occurs. If the system is biased towards ignoring anything that could potentially be personal, some real work-related information will be lost. However, if it is biased towards including information that *could* be work-related, some personal information may be included in the knowledge base and the resulting privacy violation can discourage involvement.

A related privacy issue is whether the resulting information in the knowledge base is linked to the employee who generated it. Anonymity reduces the risks to employees from

personal information being included. But because knowledge is extremely context dependent, the meaning of information can be lost when the identity of the employee is not provided. Alternatively, the system could maintain identities, but not provide them to users. Thus if an employee has a question about context, an anonymous communication could be sent to the employee responsible for entering that information into the system so he can provide context or additional details.

Participation policies are also critical, particularly when partners and customers are included. Privacy and productivity concerns often lead many employees to opt out of the system when this is permitted. Policies can be customised so that each participant has a different set of options as to which channels can be included. For example employees may be required to have their documents and emails scanned, but have the option to opt-out of telephone monitoring. Customers generally have the option to opt-out of all monitoring unless a significant benefit is provided to them from inclusion in the system. However, Rosalski [6] reports on the added value of participation by partners and customers.

Active systems require participants to provide information directly. They require that participants recognise when valuable information has been created and are willing and able to input it into the system. The additional time and effort required often reduce participation and thus participation management becomes critical. Employees must receive tangible benefits from the system [17]. However, when participants provide information directly, they can code it appropriately and thus reduce the introduction of errors in the interpretation stage considerably. This adds to the value of the system for employees receiving the information.

With both kinds of systems, it is much easier to collect embrained and encoded knowledge. Employees may not even be aware of the embodied knowledge they possess and may be unable to articulate it. Considerable work remains to be done on KMS interfaces to assist employees in entering this kind of knowledge. Embedded knowledge is difficult to collect passively because it is not often expressed in a tangible way during normal employee communications. Even for active systems, embedded knowledge is difficult to collect because of articulation difficulties. The interface must also be compatible with the mental model the employee has of the information. Even if the employee can articulate the information, he/she may not be able to confer this into a format accepted by the KMS interface.

3.2 Storage

Once the raw data has been captured, the primary challenge is to identify which data are organisationally relevant and should be included in the KMS. This filtration process is very difficult to automate because current artificial intelligence technology is not sufficiently sophisticated to predict what could be important to future business decisions. Avoiding redundancy is also problematic because employees are likely to conceive of and articulate the same information in different ways. Many systems are biased towards recording anything that could be useful, but this adds considerably to the storage requirements.

Some KMS simply store each entry as a full text, audio, or even video file that can be scanned for keywords by users of the system [6]. This is not practical as the volume of data increases and neglects the advantages of allowing the system to code the stored data, converting it into useful information. But for small organisations that only scan text

channels, it is a feasible solution. Larger organisations can only use this method within very limited domains. The alternative is to create data models for each domain and context so that data can be coded. For active systems, this is straightforward because the employee is responsible for determining which information fits the required parameters. For passive systems, more sophisticated data analysis algorithms are currently under development. However, no commercially available KMS can perform this function reliably, especially for audio or video inputs.

Accuracy filters are also critical to prevent erroneous data from entering the system. Passive systems are particularly vulnerable to inaccuracies because they can misjudge the context or miscode particular concepts. Most passive systems are thus of the full text variety. But even active systems are subject to inaccuracy from employee error or an incompatibility between the employee's intention and the design of the data models used to format the input interface. Context is difficult to judge when the employee does not know in what domains the information may be used in the future.

A second part of storage is to code the information based on the level of confidence relative to the appropriate domain and context. For active systems, this confidence is provided directly by the user. The user may input a confidence level for each context separately. For passive systems, coding can be inferred from the context using semantic analysis, but this requires that confidence indicators are verbalised and that the system can interpret them. Current systems are not able to accomplish this. Often, the confidence related to data is context-dependent and thus there may be a complex matching between particular items and confidence ratings for different domains. This also remains a challenge for future designs of KMS.

3.3 Interpretation

Full text systems merely need to store a database of keywords and associate each with relevant files. But the future of knowledge management lies in the interpretation of information to generalise contexts and domains and even to create new knowledge. Auditing also becomes more accurate once interpretation has been implemented.

During the early stages of development, an interpreting knowledge base must take information from multiple sources and aggregate it in a way that is at the very least navigable by users. More advanced systems should also be able to transform diverse sets of unrelated data into a semantic network of applicable knowledge. Adding context and confidence ratings to the semantic network makes it even more powerful. This is the key step of true knowledge management, but is one that still requires a considerable amount of development before KMS systems are able to do it effectively with the context-dependent, real world information that is most often encountered. Currently, transformation processes are only conceivable in limited domains such as customer service [18] or for specific technological processes.

Basic interpretation requires only the creation and population of data models. However, when the KMS can take information from different areas of the organisation and systematically meld it into a generalised semantic net, the power of the system expands exponentially. Modularising the network according to specific domains can be used to reduce the complexity, but this also limits the system's generalisability and power. Ultimately the power of knowledge management is to mine the interconnectedness of a full semantic network and create new relationships. Emergent knowledge that was previously unknown to any particular individual can be created by

the system itself. This process requires a partnership of technological solutions with active interpretation by human experts. Interpreting information is the most problematic and least understood in the development of a KMS. Significant advances in artificial intelligence are necessary to implement the interpretation stage. However, this holds incredible promise for the future.

The confidence coding process is also complicated in the interpretation stage. Extrapolating confidence levels from one domain to others can be accomplished actively by querying the original employee, if identity was maintained. Otherwise, the query can be sent to a department head or project manager, or inferred from the context in which the data was collected.

3.4 Dissemination

Dissemination is about getting the interpreted and formatted knowledge to the right person at the right time. A confluence of technology, organisational coordination, and administrative policy must be used to achieve the dissemination stage. Selection of appropriate media and channels of communication according to the needs of the target employee is also critical.

The dissemination of organisational knowledge through an intranet based KMS is constrained both by security concerns and by the perceived utility of the knowledge base by potential users. Security can be controlled through authorisation policies and authentication technology. Authorisation can insure that each user is limited in what kinds of information he/she can access. Authentication can use encryption and firewalls to verify the identity of users accessing the system. These technologies continue to progress. Maximising the benefits of the knowledge base to the organisation requires constant evolution of authorisation rules depending on the sensitivity and applicability of the information to a diverse set of participants. The complexity of this problem requires constant supervision and attention. The value of the KMS is increased by the inclusion of customers and partners [5], but this also reduces security and makes authentication increasingly difficult. This is an added challenge particularly for virtual organisations.

Perceived utility is a socialisation process that must be achieved when the knowledge management system is first implemented. The paradox of perceived utility is that the development time at which it is most critical to maximise participation in the KMS is at the beginning when there is little information available and considerable information to collect. However, this is also the time that it is least valuable to users. Participants develop utility perceptions very quickly upon the employment of new systems and these are often strongly coded along affective dimensions. Users decide immediately whether they like it or hate it, and that strongly correlates with future use. Specific management processes are critical at the onset to maximise perceived utility and enhance participation. Complicating this issue is the reality that KMS need time to develop. Stepanek [17] recommends making participation mandatory until the knowledge base has a chance to grow and then considering whether to allow employees to opt-out.

As with the capture stage, dissemination interfaces also can be active or passive. Active systems require employees to request data and provide parameters describing their need. The system can search its knowledge base for the answer to the question, or pass along the question to an expert that has been identified in this area [6]. Passive systems monitor the employees' activities and provide suggestions, either with direct information or links to stored documents. Dissemination interfaces have many of the same challenges

for participation management and privacy as the capture stage. For large systems with passive dissemination, there is a danger that users will be inundated with suggestions. Controls must be implemented or users allowed to set preferences themselves to reduce the quantity of contacts.

Disseminating the confidence information in a way that will be accurately interpreted by users is problematic. Wise [19] argues for the importance of calibrating the system user to the abilities and limitations of the information provided by the system. This can be accomplished through training, or by providing detailed confidence descriptions during dissemination. Even when the KMS is sophisticated enough to present employees with a context-appropriate and quantitative estimate of confidence, research from the decision support system domain has shown that these are often not considered fully, perhaps because of individual factors such as trust and self-confidence [19]. When users trust a system in general, they overestimate its validity and may not consider low confidence ratings. The reverse may also occur.

3.5 Auditing

Auditing is the stage most often neglected in the implementation of KMS. Changes in market dynamics, marketing objectives, technological advances and other developments reduce the accuracy and applicability of information, even when it was accurate at the time of entry. Confidence levels change almost immediately after they are entered into the system. Furthermore, additional codes and modifications of particular facts must be appended to the system as contexts change or more data is collected. Similarly, when knowledge has aged past its relevance or applicability, it should be removed from the knowledge base. As the size and complexity of the knowledge base increase, this task becomes more difficult. Some systems approximate the usefulness of information according to how often it is used [18]. Confidence levels can be automatically reduced as time passes, and after a set period the information can be deleted. This can be correlated with time or with the frequency of use. Modelling this strategy into a semantic network can also be accomplished by varying the strengths of connections between concepts according to the frequency of use of each component part.

Another improvement that can be implemented through the auditing process is to employ subject matter experts to evaluate the information, the modules, and the connections among them to manually improve the network. For large knowledge bases, this can be a time-consuming process, but can substantially increase the validity and reliability of the KMS.

4 Challenges to knowledge management systems

Jacko et al. [8] list many of the challenges to the effective implementation of KMS. Technologically, both hardware and software advances are needed. The development of systems to transform individual bits of data into user centred, highly distributed, semantic networks is critical. Compatibility and data management also will continue to challenge KMS development.

There are also several management challenges. Widespread implementation of KMS can burden many organisational rules and norms. There are many management styles that do not support the extensive sharing of information. KMS can also increase the amount

of time workers spend processing information rather than implementing practiced routines. Participation management is also a recurring challenge and will remain so until new motivation and compensation strategies are developed.

A third significant challenge to the effective management of knowledge is the implications for the possession and exercise of power within the organisation. Individuals can wield knowledge as a tool in the acquisition and employment of power for personal gain. Because effective knowledge management can diminish the power associated with knowledge, individuals who use knowledge in this way often resist the implementation of KMS.

5 Conclusion

The effective implementation of a KMS requires the combination of appropriate IT technology, management control, expert semantic processing, and constant supervision and evolution. In the right environment, knowledge management can be a powerful tool to support rapid advancement of an organisation's products and services, both internal and external. This leads to a large return in investment (ROI) and direct benefits to the bottom line. Argote [20] suggests that the ability of an organisation to learn explains the performance differences among competitors.

However, management issues such as participation policies, privacy policies, access restrictions, and the technological constraints of channel bandwidth, data mining algorithms, and storage capabilities, create substantial challenges to implementation. In the future, KMS will likely provide substantial competitive advantage to those organisations that successfully use them. Because of the time required to develop extensive knowledge bases, organisations should begin to construct them now.

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