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A Knowledge Management Application to Support Knowledge Sharing in a Design Engineering Community

Brian Donnellan
Analog Devices, Inc., brian.donnellan@analog.com

Brian Fitzgerald
University of Limerick, bf@ul.ie

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Brian Donnellan
Design Department
Analog Devices Inc.
Limerick, Ireland
brian.donnellan@analog.com

Brian Fitzgerald
Dept of C.S.I.S.
University of Limerick
Limerick, Ireland
bf@ul.ie

Abstract

The changing competitive landscape has brought new forces to bear on the manner in which new products are developed. These forces have put the creation and dissemination of knowledge at the centre of many firms' new product development (NPD) strategies. Organizational models to support NPD have evolved over the years and a significant aspect of this evolution has been the emergence of organizations that are decentralized and distributed across the globe. Improvements in communication infrastructure have facilitated this trend. These new organizational forms have placed stresses and strains on firm's ability to efficiently transfer knowledge across its organization units and it has been observed that knowledge dissemination can run aground once organization unit boundaries are encountered. A small number of empirical analyses of knowledge management systems (KMS) applications to support new product development have been done. These analyses have pointed to a dual requirement in this area – firstly, an organizational environment that promotes knowledge dissemination and secondly, an IS infrastructure to support collaboration in and across new product development teams. While some of the extant literature on KMS to support knowledge dissemination stresses the importance of "people-to-people" KMS applications and the area of knowledge discovery is starting to get attention, there appears to be a dearth of published material on the issues surrounding the actual implementation of such systems in an industrial setting. In particular, the use of such systems in the context of NPD organizations does not appear to be well understood. This research hopes to address some of these shortcomings. This paper focuses on an application that has been developed by the Technical and Marketing IS (TMIS) group in ADI's NPD organization. The purpose of the application is to facilitate the sharing of technical knowledge in the design engineering community in ADI.

Keywords

Knowledge sharing, knowledge management, new product development, codification, personalization, yellow pages.

1. Introduction

Organizations engaged in NPD are striving to cope with the rapid rate of technology development, change of customer's needs, and shortened product life-cycles. KMS are systems that provide an infrastructure to facilitate knowledge creation, storage, distribution and application. KMS can be designed to support NPD by

(i) Improving the sharing of knowledge and best practice across the organization

(ii) Providing a faster solution to technical problems and hence reduce time-to-market

(iii) Accelerating innovation rates by bringing diverse views to bear on an issue

(iv) Breaking down geographic/organization barriers

There is much debate on the effectiveness of IS in supporting KM initiatives. Some researchers argue that capturing knowledge in a KMS can inhibit learning and may result in the same knowledge being applied to different situations even when it might not be appropriate (Cole 1998). Also, it has been argued intranet technology can even be used to inhibit rather than promote knowledge transfer (Newell, Scarbrough et al. 1999). Other researchers contend that the application of IS can have a positive influence by creating an infrastructure and environment for strengthening and accelerating KM initiatives. This is achieved by actualizing, supporting, augmenting and re-inforcing knowledge processes by enhancing their underlying dynamics, scope, timing and synergy (Vance and Enyon 1998), (Hendriks and Vriens 1999).

The focus of this paper is on the development and implementation of a KMS application to address the challenge of providing a mechanism by which new product development staff could *easily* make their work more easily "discovered" by members of the product development organization outside of their own organization unit. The application is called docK (digital-online-cache-of-Know-how) and is being implemented in ADI's NPD organization.

2. Research Objective And Research Method

2.1 Research Objective

There are, broadly, two common applications of IS to support KM initiatives: (1) the use of repositories to codify and subsequently reuse knowledge and (2) the creation of corporate knowledge directories (so-called "Yellow Pages"). The essential difference between these applications is whether the organization in question is motivated by a goal to transmit knowledge by making it easy to locate the relevant experts or motivated by a goal to encapsulate knowledge in a form that makes it suitable for ease of dissemination. Getting the balance right between these approaches would appear to be an important consideration in the development of a knowledge management program and there appears to be little empirical research published in the literature to provide insight on how to get the balance right. This research is concerned with analyzing the development and implementation of a KMS application whose contribution space lies between the two applications mentioned above. The aim of the application is to make the new product development community aware of their colleagues' technical contributions so that they may subsequently be contacted and offer their insights on the topic for the benefit of the community as a whole.

"Conventional explanations view learning as a process by which a learner internalizes the knowledge, whether "discovered," "transmitted" from others, or "experienced in interaction" with others." (p.47) (Lave and Wenger 1991). However, before one can initiate such a process, whether through discovery or interaction, there must be a mechanism by which people can easily find out what knowledge is being created in the organization and by whom. The knowledge being sought is, in fact, knowledge about knowledge or “meta-knowledge” (Swanstrom 1999), (Kehal 2002). Meta-knowledge attempts to provide answers to questions such as “Where can I get information about a particular technical topic? How can I find out more about this topic? Is there work in progress in this organization on this topic?”

The objective of this research is to analyze the development and implementation of a KMS application that provides meta-knowledge to an NPD organization by making it easy for members of the technical staff to publish and locate technical reviews, notes, articles etc. - items which previously may have required several emails and phone calls to track down. The KMS application is called “docK”.

2.2 Research Method

A research method which has proven useful when research needs to be closely aligned with practice is that of action research (AR) (Avison *et* al., 1999, 2001; Baskerville, 1999; Oates & Fitzgerald, 2001). Typically, an AR project is a highly participative model where researchers and practitioners focus on a real business project or problem as a starting point. Thus, all the associated risk and unpredictability of a real organizational situation is factored in from the outset.

(Lewin 1947) originally described the action research cycle as having four basic steps: diagnosing, planning, acting and evaluating. Lewin saw the process as a “spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action” (p.206). The action research model being applied in this research is similar to that described in (Susman and Evered 1978) and sees the research process as a five phase cyclical process containing the following discrete steps: diagnosis, action planning, action taking, evaluation and learning.

The AR method recognizes that a research project should result in two outcomes, namely an *action* outcome and a *research* outcome. Taking each in turn: firstly the action outcome is the practical learning in the research situation. Thus, a very important aspect of the research is the extent to which the organization benefits in addressing its original problem. This serves to ensure the research output is relevant and consumable to practice. Secondly the research outcome is very much concerned with the implications for the advancement of theoretical knowledge resulting from the project.

The authors were interested in both these aspects in this study. One of the co-authors is a full-time employee in the NPD organization in ADI. ADI is a world leader in the design, manufacture, and marketing of integrated circuits (ICs) used in signal processing applications. Founded in 1965, ADI employs approximately 8,600 people worldwide. The problems that were identified in ADI were (i) a lack of awareness of what knowledge was being created in the Design organization and by whom, and (ii) the absence of a mechanism by which product development staff could *easily* make their work more easily “discovered” by members of the product development organization outside of their own organization unit.

3. Literature Review: Knowledge Management Applications To Support Knowledge Dissemination In Engineering Design

Recent studies indicate, on one hand, the importance of co-workers as sources of knowledge and on the other hand, the difficulties associated with effectively transferring knowledge in the workplace (Teigland, Fey et al. 1999), (Hansen 1999). (Danziger and Hull 2000) conclude that employees tend to seek answers to system questions primarily from the most informal, personal sources, and especially from coworkers, not from the most technologically-based sources. Their results are summarized in Table 1.

Table 1 Frequency and Effectiveness of Sources used to Seek Answers to System Questions in a High Tech organization (adapted from (Danziger and Hull 2000))

Source	% of employees using source at least 1-2 times per month	% of employees who rate source very good
Coworkers	63.4%	44.5%
Supervisor	28.7%	25.7%
IT Dept	28.6%	23.4%
Printed Materials	26.7%	14.0%
Telephone Helpline	16.9%	12.6%
OnlineHelp System	16.4%	7.8%
Website	11.5%	7.6%

The research of (Danziger and Hull 2000) points to the importance of adopting a KMS approach that supports "person-to-person", as well as "person-to-document" knowledge transfer mechanisms. The "person-to-person" approach has been getting a lot of attention recently in the literature. This general approach has different labels associated with it e.g. Hansen et al. use the term "personalization" (Hansen, Nohria et al. 1999), Swan et al. call it a "community" approach (Swan, Newell et al. 1999) and Alavi et al. call it an "informal impersonal" approach (Alavi and Leidner 2001). All of these researchers share a common conviction that, to be successful, a KMS strategy should include mechanisms that help people to have a discourse with knowledgeable colleagues.

KMS applications can help address the challenges that firms face in extending individuals' reach beyond their formal communication lines. One of the critical issues in organizational knowledge distribution is that individuals with a need to know may not be aware of the knowledge sources in the organization. The search for knowledge sources is usually limited to immediate co-workers in regular and routine contact with the individual. However, individuals are unlikely to encounter new knowledge through their close-knit work networks because individuals in the same clique tend to possess similar information (Robertson, Swan et al. 1996).

This problem is also identified by Lave et al.. "Conventional explanations view learning as a process by which a learner internalizes the knowledge, whether "discovered," "transmitted" from others, or "experienced in interaction" with others." (p.47) (Lave and Wenger 1991). However, before one can initiate such a process, whether through discovery or interaction, there must be a mechanism by which people can easily find out what knowledge is being created in the organization and by whom.

The knowledge being sought is, in fact, knowledge about knowledge or "meta-knowledge" (Swanstrom 1999), (Kehal 2002). Meta-knowledge attempts to provide answers to questions such as "Where can I get information about a particular technical topic? How can I find out more about this topic? Is there work in progress in this organization on this topic?" The docK KMS application tackles these challenges by making it easy for members of the technical staff to publish and subsequently locate technical reviews, notes, articles etc. - items which previously may have required several emails and phone calls to track down. This is achieved by using (a) sophisticated resource discovery tools, and (b) rich varieties of resource description.

3.1 (a) Resource Discovery Tools

Resource discovery tools have been characterized as falling into two categories – search engines (SEs) and digital libraries (DLs). The first generation of SEs and DLs defined the basic structures of indices, directories and libraries. The second generation put the first generation tools to work in an operational setting. The third generation emphasized popularity measures such as links, usage and time as well as the use of parallel computing power and advanced search techniques (Hanani and Frank 2001). The distinctions between the generations of SEs are summarized in Table 2.

Table 2 Three Generations of Search Engines (adapted from (Hanani and Frank 2001)**)**

Generation	Ses	Features	Examples
1	Basic-SE	Robots, indices, directories, basic user interfaces	Yahoo, LookSmart, Excite, Lycos, HotBot, Infoseek
2	Meta-SE	Multi and mega search	MetaCrawler, SavvySearch, DogFile
3	Popularity-SE	Popularity based on links, usage, time measures	Google, Clever, DirectHit, FAST, FizzyLab

3.2 (b) Resource Descriptions

Metadata is used to provide a richer resource description for information on the WWW. *Meta* is used to mean a level above a target of discussion or study. Metadata is data about data and is often used in the context of data that refer to digital resources available across a network. Metadata is a form of document representation that is linked directly to the resource, and so allows direct access to the resource. Internet search engines use metadata in the indexing processes that they employ to index internet resources. Metadata needs to be able to describe remote locations and document versions. It also needs to accommodate the lack of stability of the Internet, redundant data, different perspectives on the granularity of the Internet, and the variable locations on a variety of different networks. There are a number of metadata formats in existence to provide bibliographic control over networked resources. The Dublin Metadata Core Element Set (Kunze, Lagoze et al. 1998) is one of the prime contenders for general acceptance – and is the format implemented in docK. Through the use of metadata, documents become more like databases where search, retrieval and reuse of text elements (explicit knowledge) are promoted while also giving the reader the opportunity to contact the source of the knowledge so that they may have a dialogue to enable tacit knowledge transfer (Braa and Sandahl 2000).

4 The “docK” KMS Application

Making technical knowledge available to colleagues in a format that lends itself to ease of dissemination can represent a significant impediment to those who are willing to share their knowledge. This hurdle constitutes a “barrier to entry” to prospective contributors to a KM initiative. The docK project tackles this challenge of lessening the amount of work needed to make technical knowledge available to a new product development community. It does this by taking advantage of current resource discovery technology and developing richer resource descriptions for the knowledge available in the community. The storage and search methods used in docK were designed to increase the ease with which one can find - and submit - reviews, notes, and articles - which previously may have required many emails and phone calls to track down.

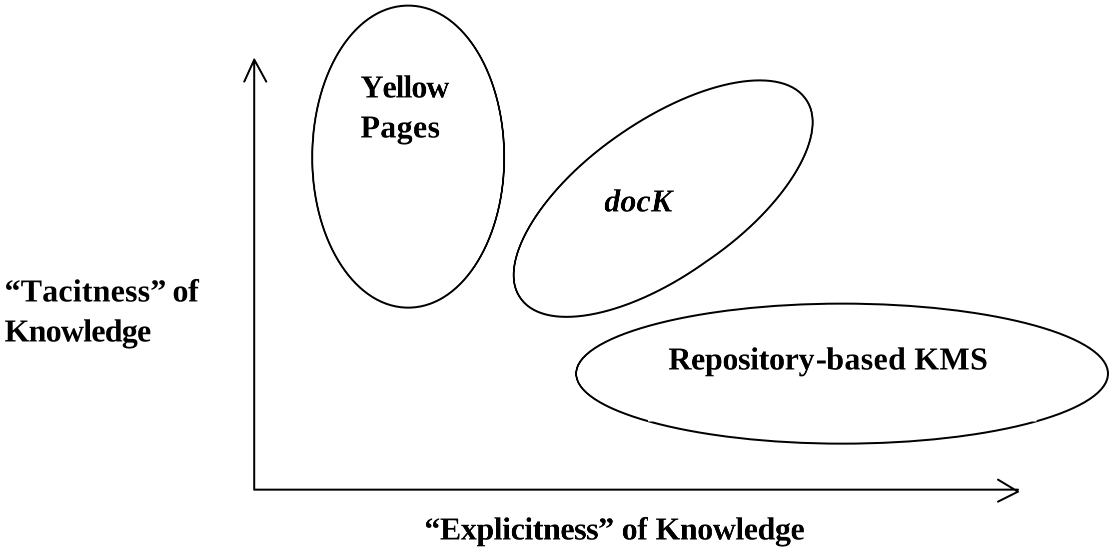
4.1 docK’s KMS strategy

Some forms of codified knowledge lend themselves to a repository-based KMS approach. These are shown in Figure 1 located in a region that contains a high degree of explicit knowledge and a low degree of tacit knowledge. A “Repository”, in this context, provides a store of previously design products that could be reused throughout the corporation. Each of the repository’s elements has an extensive support kit associated with it i.e. thorough documentation, contextual information about previous usage, data formats compatible with existing NPD systems, etc.

Other forms of knowledge are best managed by promoting human interaction and KMS applications such as “Yellow Pages” are located in a region that a high degree of tacit knowledge and a low degree of explicit knowledge. Yellow Pages are applications that provide a centralized database of user knowledge profiles. They offer users multiple ways to find user profiles. Participation is usually voluntary (i.e. no automatic profile creation). Users can create and maintain their profile’s visibility and access. An example is described in (Carrozza 2000).

The approach being taken by docK is depicted in Figure 1 as being in the region between the two extremes described earlier. The intent is to provide a KMS application that complements the two other approaches. It has the advantage of providing direct access to more content than a Yellow Pages application, but does not suffer the disadvantage of requiring the extensive amount of pre-processing and preparation required by repository-based systems.

Figure 1 KMS strategies



4.2 Resource Discovery Tools in docK

KMS architectures have been proposed in the literature by (Tiwana and Ramesh 2001), (Tiwana 2000), (Conway and Sligar 2002), (Satyadas, Harigopal et al. 2001) and (Zack 1998). The architectures benefit from the generic advantages of web-based systems including platform independence/portability, integration with legacy systems, scalability, distributed connectivity and a ubiquitous, consistent client interface (Tiwana and Ramesh 2001). Web-based KMS architectures have components to support knowledge management initiatives.

These components include

- mapping components to create repositories with context e.g. SQL d/bases
- flow components to provide paths across organizations e.g. intranets
- mining components to locate and extract knowledge e.g. search and retrieval tools

A diagram showing the architecture of docK is shown in Appendix A. KMS architectures are typically comprised of three tiers or levels – browser level (or client level), server level and repository level. The browser level represents the most visible element of the architecture and in the context of ADI, presents users with access to docK, and other KM systems on the ADI intranet. The server level provides a link between the browser and repository levels. The server typically contains a search engine, an information architecture (i.e. a model of how the system could make inferences based on tagging and a model of how content can be grouped into related collections) as well as profiling and personalization services to identify users and target content delivery.

4.3 Resource Descriptions in docK

The docK application contains reference information about each document. The format used is based on the Dublin Core Element Set, a standard initially developed in 1995 to facilitate the discovery and retrieval of online resources. An invitational workshop held in March of 1995 brought together librarians, digital library researchers, and text-markup specialists to address the problem of resource discovery for networked resources. This activity evolved into a series of related workshops and ancillary activities that have become known collectively as the Dublin Core Metadata Workshop Series. The goals that motivate the Dublin Core effort are:

- Simplicity of creation and maintenance
- Commonly understood semantics
- Conformance to existing and emerging standards
- International scope and applicability
- Extensibility
- Interoperability among collections and indexing systems

The metadata elements fall into three groups that indicate the scope of information stored in them: (1) elements related mainly to the Content of the resource (Title, Subject, Description, Type, Source, Relation, Coverage), (2) elements related mainly to the resource when viewed as Intellectual Property (Creator, Publisher, Contributor, Rights) and (3) elements related mainly to the instantiation of the resource (Date, Format, Identifier, Language) (Kunze, Lagoze et al. 1998). The “docK” implementation of the Dublin Core is described in Table 3.

Table 3 Implementation of Dublin Core Metadata Element Set in "docK"

Label	Standard Definition	ADI Implementation
Title	The name given to the resource, usually by the Creator or Publisher.	Implemented as per standard definition.
Creator	The person or organization primarily responsible for creating the intellectual content of the resource. For example, authors in the case of written documents, artists, photographers, or illustrators in the case of visual resources.	Currently not implemented but may be used in the future to distinguish between primary and secondary authors.
Subject	The topic of the resource. Typically, subject will be expressed as keywords or phrases that describe the subject or content of the resource. The use of controlled vocabularies and formal classification schemes is encouraged.	Implemented as a controlled vocabulary containing a set of keywords drawn from ADI technical terminology. Recommendation is to use three keywords.
Description	A textual description of the content of the resource, including abstracts in the case of document-like objects or content descriptions in the case of visual resources.	Implemented as per standard definition.
Publisher	The entity responsible for making the resource available in its present form, such as a publishing house, a university department, or a corporate entity.	The publishing entity is described as the business unit with whom the publisher is affiliated.
Contributor	A person or organization not specified in a Creator element who has made significant intellectual contributions to the resource but whose contribution is secondary to any person or organization specified in a Creator element (for example, editor, transcriber, and illustrator).	Implemented as information about the person who contributed the document to dock. In most cases this is the same person as in the "author" field.
Date	A date associated with the creation or availability of the resource.	Implemented as (i) creation date and (ii) modification date
Type	The category of the resource, such as home page, novel, poem, working paper, technical report, essay, dictionary. For the sake of interoperability, Type should be selected from an enumerated list that is currently under development in the workshop series.	Implemented as a controlled vocabulary using appropriate labels e.g. Conference Paper,, Architecture Review, etc.
Format	The data format and, optionally, dimensions (e.g., size, duration) of the resource. The format is used to identify the software and possibly hardware that might be needed to display or operate the resource.	The formats supported are .pdf, .ppt, .doc and plain text (.txt).

Identifier	A string or number used to uniquely identify the resource. Examples for networked resources include URLs and URNs (when implemented). Other globally-unique identifiers, such as ISBN or other formal names are also candidates for this element.	(actually there are several "identifiers")
Source	Information about a second resource from which the present resource is derived. While it is generally recommended that elements contain information about the present resource only, this element may contain metadata for the second resource when it is considered important for discovery of the present resource.	Implemented as per standard (parent document).
Language	The language of the intellectual content of the resource.	Not implemented. English is the default language.
Relation	An identifier of a second resource and its relationship to the present resource. This element is used to express linkages among related resources. For the sake of interoperability, relationships should be selected from an enumerated list that is currently under development in the workshop series.	Implemented as three relationship options (i)"replaces", (ii)"is replaced by" and (iii)"see also".
Coverage	The spatial or temporal characteristics of the intellectual content of the resource. Spatial coverage refers to a physical region using place names or coordinates. Temporal coverage refers to what the resource is about rather than when it was created or made available. Temporal coverage is specified using named time periods.	Not implemented at present.
Rights	A rights management statement, an identifier that links to a rights management statement, or an identifier that links to a service providing information about rights management for the resource.	Not implemented at present.
File Name	Not in standard.	A target file that is uploaded to docK by the author.

4.4 docK Deployment

The deployment strategy for docK was executed as follows:

1. A prototype system was developed and demonstrated to a focus group chosen from the design engineering community in ADI.
2. Feedback was collected and collated by the project's lead developer.
3. The original feature set was revised and augmented based on the user feedback.
4. The application was then demonstrated to a broader cross-section of the ADI technical community at the corporation's annual technical conference.
5. Lead users were identified and they volunteered to guide early versions of the application.
6. docK has now been released in three NPD sites (two in U.S., one in Europe).
7. The next project milestone is to demonstrate its revised and expanded capabilities, again, at the company's annual technical conference. The feedback received at that conference will influence the plans to extend the application to other sites across ADI.

Lessons learned by the development team include: the importance of senior management sponsorship, infrastructure support (robust systems, networks and access control protocols), cultural acceptance of the application (especially among prominent members of the technical community) and the need for adequate resources/staffing.

5 Conclusions And Future Work

This paper describes a KMS application that has been developed by the TMIS group in ADI. The approach being pursued is based on an understanding of current approaches to KMS development and implementation. The work builds on earlier work by (Hansen, Nohria et al. 1999), (Swan, Newell et al. 2000) and (Markus 2001) and leverages current resource discovery and resource description techniques. The aim of the project was to provide a mechanism by which new product development staff could *easily* make their work more easily available to members of the product development organization outside of their own organization unit.

The project recognizes the weaknesses in the scope of some current KMS applications. These weaknesses have been summarized as "barriers-to-entry" for KMS systems because they either present prospective users with too much work to get their knowledge encapsulated (in the case of repository-based systems) or provide too little knowledge for the prospective user to find the system worthwhile (in the case of "Yellow Pages"). docK attempts to provide the users with a balanced approach that is tailored to make it easy for prospective users of the system to add their technical documentation in a manner that results in enough useful knowledge being made available to the general design community. Getting the balance right between these approaches would appear to be an important consideration in the development of a knowledge management initiative and this research adds to the small (but growing) body of empirical research published in the literature.

At present docK is being deployed in three sites in an NPD organization. Possible future directions being contemplated for docK include broadening the range of applicability to include NPD knowledge other than design (e.g. test) as well as the development of a directory-based utility to add some "Yellow Pages"-type functionalty.

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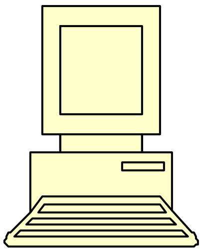
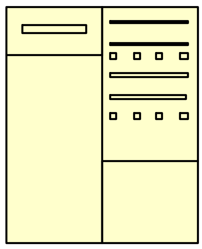
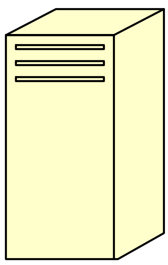
The development and implementations of the "docK" applications described in this paper is being led by the TMIS group in ADI. The authors wish to thank Beth Rhinelander, Tanya Mollenauer, Michelle Breen and Colin Lyden for their insights and helpful elucidations.

Appendix A: docK Architecture

Function		Technology/Systems
Clients on users' desks that present KMS user interfaces for data input, viewing and manipulation. User authentication also handled in this tier.		Internet Explorer, Netscape. C3-level UNIX security.
A web server that acts as a knowledge aggregation hub. Documents are polled to capture Dublin Core metadata such as author, subject and title. References to documents are indexed in search engine.		Google Search Engine. Dublin Core Metadata
Manages and provides access to the store of documents. Data integrity (access rights, auditing backup).		SQL Database

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