Developing an Advanced Environment for Collaborative Computing

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Abstract

This paper presents the research directions of a project seeking to augment advanced collaborative web-based environments with knowledge management capture. Knowledge management tries to organize and make available important know-how, whenever and wherever is needed. Today, organizations rely on decision-makers to produce "mission critical" decisions that are based on inputs from multiple domains. Additionally, learning companies benefit by not repeating costly mistakes, and by reducing time-to-market in Research & Development projects. Group-decision making tools can help organizations make better decisions by capturing the knowledge from groups of experts. Furthermore, organizations that capture their customer's preferences can improve their customer service, which translates to larger profits. Therefore, collaborative computing provides a common communication space, improves sharing of knowledge, provides a mechanism for real-time feedback on the tasks being performed, helps to optimize processes, and results in a centralized knowledge warehouse. The project will begin by developing a collaborative computing environment based on Postdoc, a "government-off-the-shelf" document management software developed at NASA-Ames Research Center. Future directions for research are presented as well.

Knowledge Management and the Organizational Context

The ideal decision-maker has a profound understanding of specific domains that influence the decision-making process coupled with the experience that allows them to act quickly and decisively on the information. This profile of the ideal decision-maker usually corresponds to someone who has lengthy experience and implicit knowledge gained from years of observation. The following four underlying trends are raising the stakes in the decision-making scenario:

1. Increasing complexity of the underlying domains
2. Accelerating volatility within each domain is increasing;
3. Speed of responsiveness to take action based upon subtle changes within and across domains is decreasing; and
4. Individuals with decision-making authority potentially have less tenure with the organization than ever before, due to such factors as high employee turn over rates.

Supporters of the knowledge management (KM) movement say "effective knowledge management pays off in fewer mistakes, less redundancy, quicker problem solving, better decision making, reduced research development costs, increased worker independence, enhanced customer relations, and improved services. In effect, the advantages resulting from KM add up to keep the company at least a few steps ahead of its competitors" (Stuart, 1996). Since knowledge management systems (KMS) provide access to explicit company knowledge, it is easy to learn from previous experiences. "Learning companies" benefit by not repeating costly mistakes, and by reducing time-to-market in Research & Development projects. Group-decision making tools can help companies make better decisions by capturing the knowledge from groups of experts. Companies that capture their customer's preferences can improve their customer service, which translates to larger profits" (Becerra-Fernandez et. al. 1998a). Eliciting and harvesting knowledge changes a normal organization into a "learning" organization capable of quickly and efficiently finding solutions to new problems, as well as, reusing and adapting previous solutions.

Assessing intellectual capital at NASA

Current organization structures have become much more complex, both technologically and culturally. Technology is not only complex, but changes at an ever increasing pace. Many resulting problems and failures are too difficult for any individual person or organization to solve. Solutions require teams to share their knowledge in agile, spontaneous collaborations. Since requisite expertise will not all reside in the same organization, nor be geographically co-located, virtual networked teams are needed. Empirical research has demonstrated that diversity of knowledge leads to better collective performance, therefore, technology must enable

and enhance collaboration processes. Technology should facilitate cooperation between Government research groups and commercial developers, automated knowledge capture and representation, and encouraging diversity and creative risk taking.

A functional KM system requires that knowledge be elicited/created, shared, managed, and leveraged by a balanced combination of: people, process, information technology applications, and organizational culture. In order to assess the areas of intellectual capital for Kennedy Space Center (KSC), a Knowledge Management Assessment (KMA) for KSC was designed and implemented between February and April of 1998 (Becerra-Fernandez, 1998c). Following is an excerpt from the summary of observations from the KMA:

1. Center-wide lessons learned repository: Five of the eight interviewed groups expressed the need for a Center-wide lessons learned repository..
2. Collaborative tools: Of the 8 technical groups interviewed, 6 expressed a need for Internet/Intranet based collaborative tools that capture knowledge as teams create it. Implementation of appropriate collaborative tools would also address the need to enhance virtual communication among departments and teams; as well as between KSC and other government agencies and universities.
3. KM procedures to harvest knowledge: Five of the eight interviewed groups expressed the need for procedures to harvest organizational knowledge.
4. Electronic document storage: Four out of the eight interviewed groups addressed the need for proper electronic document storage that would allow departments and teams to share work files and relevant data.

From these observations, a list of recommendations was developed. The following is an excerpt of the recommendations:

1. Reorganizing: The Learning Organization of the 21st Century will also require the implementation of tools that will enhance the collaboration across functional organizations. Collaborative computing software is an effective way to enhance team collaboration, particularly that of virtual teams whose members work within the spectrum of "same time/same place" to "different time/different place".
2. Establishing a centralized knowledge repository: All of the KSC groups interviewed expressed the need to facilitate intra-departmental linkages, particularly aimed at enhancing access to information archived in isolated departmental databases.

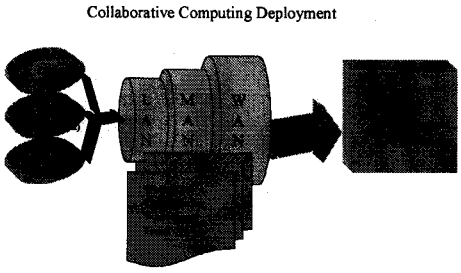
Project Description: Augmenting the capabilities of the Postdoc software

One tool frequently touted under the auspices of KM is document management. At the core of a document management system is a centralized repository, an electronic storage medium with a primary storage location that affords multiple access points. The document management system essentially stores information. A document management system unifies an aggregate of relevant information conveniently in one location through a common interface. Document management builds upon the central repository by adding support to the classification and organization of information, unifying the actions of storage and retrieval of documents instituted over a platform independent system. The document management collaborative application increases communication, thus allowing the sharing of organizational knowledge.

A workflow tool provides a method of capturing the steps that lead to the completion of a project within a fixed time frame, and in doing so, provides a method of illustrating such steps. Currently the Postdoc software does not support workflow functionality. Workflow systems can be useful for projects by enacting its elemental tasks, as well as by providing a mechanism, for the analysis and optimization of the entire processes detailing the project. Another benefit of using a workflow system is that it provides the user with an audit of necessary skills and resources prior to project initiation. Workflow systems provide a template for the replication and reuse of stored processes. Finally, workflow tools can also serve as a training tool since they provide a broad overview with detailed operations of tasks as well as identification of "weak links" in a process.

A collaborative environment (which allows the informal exchange of ideas) combined with a detailed workflow (which captures process steps) is an efficient method of streamlining business practices. A document management system unifies an aggregate of relevant information conveniently in one location through a common interface. Categorizing and processing information for search purposes provides a detailed knowledge warehouse. The collaborative application increases communication, thus allowing the sharing of organizational knowledge. Although there are benefits of using these three tools (document management, workflow, and groupware), independently of each other, their integration augments their individual contributions. The document management system essentially stores information. The workflow, which details the steps involved in completing a project, combined with a central repository that contains information relevant to a project, provides added benefits. Collaborative computing provides a common communication space, improves sharing of knowledge, provides a mechanism for real-time feedback on the tasks being performed,

helps to optimize processes, and results in a centralized knowledge warehouse.



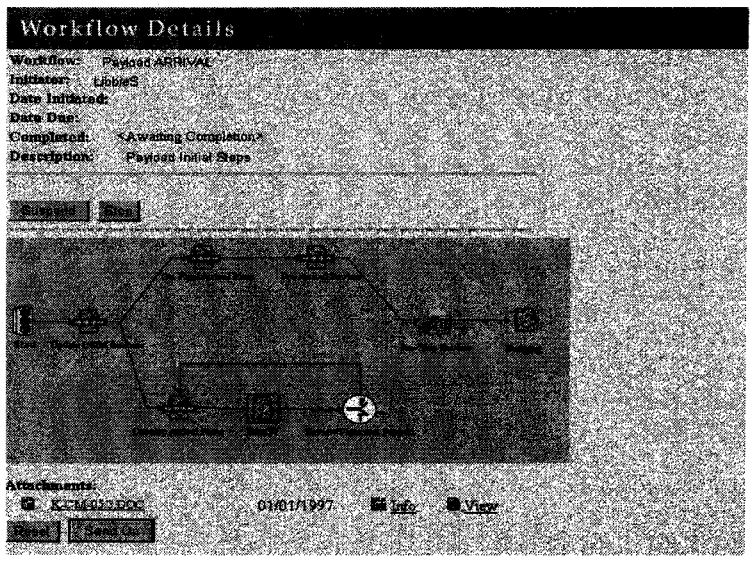


Figure 1 Collaborative Computing Deployment Structure

Figure 2 Workflow for Collaborative Computing

This project seeks to augment the current functionality of the Postdoc software environment with workflow capabilities. The addition of workflow capabilities is important in the context of allowing version control in the collaborative development of documents, such as change requests, document reviews, and proposal writing. By tracking changes in the state of the document, proposals could be drafted and submitted, then later reviewed, voted on, and totals tallied all in a virtual collaborative environment. By combining Postdoc's ability to maintain revision control with the added ability to notify users via e-mail based on the document status, dispersed groups can benefit from a true dynamic, collaborative environment. Figure 1 is a representation of the collaborative computing underlying technical architecture. The expanded workflow capability will allow sending e-mail notifications for specific changes in the state of a document. An advanced feature for automated processing of the document will also be provided in the workflow process. Figure 2 is a representation of the integrated workflow environment.

The Evolution of Postdoc

The Postdoc software required a development effort of 5 person-years of software coding and testing, beginning with the New Millennium Electronic Documentation Project in the Computational Sciences Division at NASA Ames Research Center (ARC). The New Millennium Electronic Documentation Project was the first NASA web-based Intranet defined for a very large program involving six Deep Space missions, three Earth Orbiting missions and six technology teams in 1995.

Postdoc is a multi-user, web-based application primarily for the storage and retrieval of documentation (i.e., word processing documents, spreadsheets, slides, illustrations, images, video, audio, software archives, or others). Unlike a traditional web site where the webmasters alone construct it, a Postdoc web site is "easily" constructed by its users who can login to the site to add, delete, and organize documents tailored to their choice. Users need not have any specialized web site construction knowledge or skills such as HTML or programming. Users create documents on their own computer using many popular applications (such as Microsoft® Word, Excel, and PowerPoint) then easily upload them to the Postdoc server. The server can then automatically convert them into PDF, enabling them to be viewed by anyone without the creating application. By virtue of being a web-based application, Postdoc can be used by anyone, anywhere. The only requirements to use Postdoc are a computer (be it a Macintosh, PC, or a Unix workstation), a browser (such as Netscape® Navigator or Microsoft® Internet Explorer), and an Internet connection. Although Postdoc works well for small co-located teams, by being web-based it also works very well for geographically dispersed teams, including members on travel using a laptop computer with a cellular modem. Postdoc is available for free for government use. NASA-ARC supports the deployment of this innovative tool, not only within NASA centers but also at other government agencies.

Postdoc has been very effective in meeting the targeted scope of a document management system, and continues to be used today to manage thousands of documents across many divisions of NASA. However, Postdoc's ability to support KM is limited by this initial scope and by the (dated) design and implementation. A plan is in place to re-architect the Postdoc system with a larger, more generic scope, in order to meet KM needs, as well as the growing needs of other projects throughout NASA that are looking to expand Postdoc's functionality into (often drastically) different applications.

There are certain features that need to be present in an effective collaborative environment. A collaborative environment must support electronic mail and messaging, group scheduling, electronic meeting systems, real-time data conferencing, non-real time conferencing, group document handling, workflow, development tools, groupware applications and internet based applications. In order to support KM, Postdoc needs the ability to effectively manage metadata about documents. Furthermore, Postdoc must enable users to with the ability to manage the collection and manipulation of this metadata, in order to manage the state of the document as it transitions in the workflow. The re-design of Postdoc will require the application of an access-controlled, user-extensible, object-oriented data model. Postdoc will be redesigned with a decoupled, hierarchical design, providing a "sandbox" application programming environment for end-users to develop workflow and KM functionality while ensuring security by preserving data access-control. This decoupled design also enables Postdoc components to be exchanged for alternative, often quite different components. The Postdoc redesign will also incorporate the most current, applicable technologies, standards, and protocols for web-based collaborative environments--primarily working towards compliance to and utilization of the Extensible Markup Language (XML) and Web Distributed Authoring and Versioning (WebDAV) standards and technologies. WebDAV is a set of emerging, open set of standards for web publishing architectures and is being developed and adopted by a variety of vendors and open-source projects. For example, by adding an alternate communication and presentation layer, a command-line interface, 'chat' interface, WebDAV HTTP extensions could be supported simultaneously. Alternate data storage technologies could additionally be leveraged, such as object-oriented and/or distributed database technologies, without application modification.

At the heart of the workflow tool will be an event manager. As mentioned earlier Postdoc will have to manage the metadata. The event manager will function on a schedule, which is triggered either by date and time or an event occurring. The event manager will be responsible for the timely movement or transition of the document. It will act as an intelligent agent that will track active workflow. Postdoc currently groups its users and organizes the documents into folders. A workflow process can take place between users in a group or users from different groups. User notification will continue to be handled by email with the addition of an on-line notification at login.

Table 1 highlights some of the most important features of a collaborative system and a comparison of Postdoc and some of the more popular commercial products. Lotus Notes is the most widely known and one of the pioneer systems in collaborative/groupware systems, and supports several separate tools and applications. Netscape and the World Wide Web (www) are becoming a cost-effective solution for many companies. An internal web server provides all the benefits of the www, while not accessible from the www. Groupwise is a cross platform collaboration and messaging system that facilitates gathering, accessing and communicating information. OpenInsight is a repository based development environment that provides development teams to design, develop and implement large scale business applications. Postdoc NG refers to the augmented version of Postdoc able to handle some more functionality.

Future applications of this research

A potential application of this research is the implementation of a collaborative environment within the context of the software change request process. In the current environment, Postdoc notifies users of any changes in the document. In the new developed environment, notifications will be set for specific changes that modify particular states of the document. The new expanded capabilities of Postdoc will be tested in the Software Change Request (SCR) process as follows:

1. Originator enters SCR Document into Postdoc.
2. Input notifies the appropriate System Engineer via email.
3. The System Engineer updates the SCR with a log number and other data.
4. This update notifies the Originator and the members of the Software Change Board (SCB).
5. The workflow system then automatically assigns the SCR to the SCB calendar.
6. Members of the SCB review and disposition the SCR
7. SCR is closed and appropriate notifications are sent.

In addition, the automated processing feature of Postdoc will be tested, including batch database updates, integrity checks, and vote tallies. The prototype, implemented through the integration of workflow, document management, and groupware tools, can be applied to other domains that rely on group collaborations within NASA. This application provides a mechanism

for virtual team collaboration that can be made available both inside and outside of NASA-ARC. Moreover, user access is provided through an intuitive underlying web structure.

The new augmented features of Postdoc would prove invaluable to other key processes in NASA, for example in the Payload Processing Customer Support Process. The augmented Postdoc environment with workflow, document management, and groupware capabilities would be useful to develop a prototype for collaborative computing ideal for the NASA-KSC Payload Processing Directorate. The Postdoc collaborative computing environment described here could provide the NASA-KSC Payloads Processing Directorate with a detailed audit of resources. It would allow the observation and capture of a project plan as it is being created through the document management, and provide a means of assessing the effectiveness of completed project plans with the integrated workflow analysis tools. The Postdoc collaborative computing environment would also provide an audit of hours necessary for the completion of a project through the time-framed process layout. This collaborative computing application would be able to capture organizational knowledge, including how to complete a process flow, why a process flow is performed the way it is, and what information is needed to complete a process flow. Finally, the Postdoc collaborative computing environment would enable informal as well as formal suggestions for projects, akin to an electronic suggestion box, to provide process feedback.

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Functionality	Postdoc	Lotus Notes	Netscape	Group-wise	Open-Insight	Postdoc NG
Tightly integrated collaborative environment	*	*				*
Document-centric user interface that supports rich data types	*	*		*	*	*
Electronic mail messaging	*	*	*	*		*
Group Calendaring & scheduling				*		*
Electronic meeting systems		*	*			*
Real-time data conferencing			*	*		
Non Real-time data conferencing	*			*		*
Group document handling	*	*		*		*
Moderate workflow		*				*
Supports bulletin boards		*	*			
Supports decision making		*				*
Data warehousing	*	*		*	*	*
Supports application development		*	*	*	*	*
Empowers the mobile worker & geographically dispersed groups	*		*	*	*	*
Supports general discussions		*	*		*	
Training & maintenance		*		*		*
Publish & delivery of documents	*		*			*
Status reports generated		*			*	*
Security and authentication	*	*	*	*	*	*
www interface	*	*	*	*	*	*
User constructed	*				*	*
Centralized	*	*			*	*
Supports business to business interface	*		*			*
Supports version control					*	*
User knowledge of scripting/web languages		*	*	*	*	

Table 1 - Functionality comparison between Collaborative/Groupware Systems