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Canada

Design concepts for Virtual Research and Collaborative Environments

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ABSTRACT: The research and scientific community is currently in the process of moving away from the old "information spread" model for dissemination of scientific information towards the new communication model. The most important feature in this new communication model is to include repositories of raw data on Internet servers, for use by researchers that wish to build on findings of others, or to create new knowledge by combining their own data with the data of others. This paper addresses the newly emerging paradigm of scientific knowledge collaboration as it relates to the design principles and concepts for the virtual communities of practice. A "Knowledge Portal" model is described where the Portal Web site provides free access to the Discussion Forum for scientists, practitioners and private companies, supported by the repository of scientific knowledge and by the Virtual Laboratory that is maintained as a value-added service for the community members. The proposed model is applied to knowledge collaboration in AEC/FM industry.

1 BACKGROUND

The research and scientific community is currently in the process of moving away from the old "information spread" model for dissemination of scientific information (Klein & Gwaltney, 1991), where knowledge is normally channeled through refereed academic journals and conference proceedings following the traditional Garvey-Griffith model of a scientific communication system (Garvey & Griffith, 1972). Researchers are becoming increasingly involved in publishing their articles in online-refereed journals that provide free or low fee access to scientific information (Case, 2001; Gudnason et al., 2002).

It is believed that the key to a successful knowledge dissemination strategy is to channel the knowledge to the communities of practice (Wengler, 2000) and at the same time provide means for information exchange and peer-to-peer collaboration. A new approach to scientific information dissemination is currently being developed that is based on the Virtual Laboratory model (Kondratova & Goldfarb, 2002). This online information exchange environment of the Virtual laboratory provides free Web-based access to the repository of research results and to a discussion forum for scientists, practitioners and companies-participants.

Some of the existing virtual laboratories, as for example DOE's Virtual Laboratory for Biokinetic and Dosimetric Research (2002), or a Virtual Testing laboratory on the Web (Cervenka & Branis, 2002) have already developed tools that support collaborative research and development work for research communities such as Enote electronic notebook (DOE 2000, 1999), a software system that provides researchers the ability to share a Web-based notebook with collaborating research groups, or a software-based structural testing tool developed by the ISTforCE (Cervenka & Branis, 2002).

This paper will addresses the newly emerging paradigm of scientific knowledge collaboration as it relates to the design principles and concepts for the virtual communities of practice based on the particular area of knowledge collaboration in AEC/FM industry.

2 KNOWLEDGE PORTAL MODEL

One of the possible models for a virtual collaborative research environment would be the "Knowledge Portal" model (Kondratova, Goldfarb, 2003) where the Portal Web site provides, for scientists, practitioners and private companies, free access to the Discussion Forum and to the Virtual Laboratory. The Virtual Laboratory enables joint work on common documents, databases, research projects, and contains domain-specific software tools. The maintenance of the Virtual Laboratory should be carried out by the content experts. A similar concept of a Virtual Laboratory is introduced by the UNESCO's

Electronic Support for Cooperative Scientific Research Project (UNESCO, 2003).

In order for a Discussion Forum to be a place where scientific discussion, knowledge sharing and exchange will happen, and new knowledge will be created, the Discussion Forum should be supported by a comprehensive knowledge repository (Fig 1).

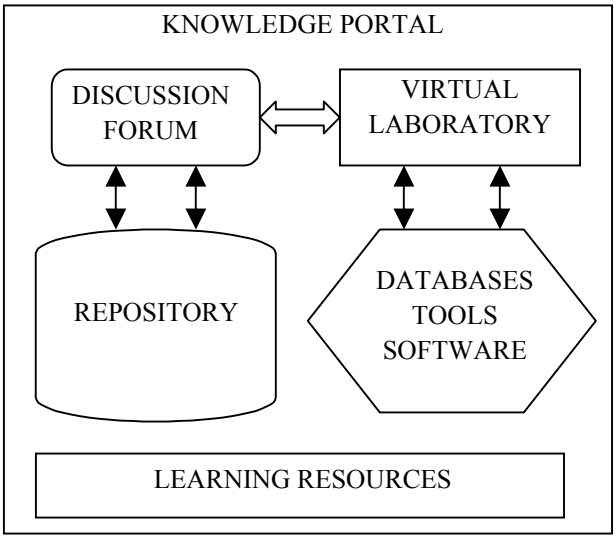

Figure 1. Knowledge Portal model

The participating research organizations, private companies, and industry practitioners can submit research artifacts (research results, photographs, reports and preprint papers) into the repository.

Data within the repository should be presented in XML format, as the XML format allows automated tools to extract the context of the data and to present it independently from the diverse formatting in documents or databases. Advanced search and retrieval tools for the repository should be based on both, content and metadata, as well as on the value-added services, such as document summarization.

A peer review process of submissions, by content experts from the user community, should be undertaken to assure the quality of submissions. A similar approach to the portal repository with quality control provided by the content experts is adapted by the oneFish research community (OneFish Community, 2003). This community developed an International Internet portal providing access to information on fisheries and aquatic research worldwide that facilitating a more efficient and effective application of research-based knowledge to the many constraints of sustainable development.

In the OneFish Knowledge community knowledge objects are submitted into the portal repository and volunteer topic editors assess the quality, value and relevance of knowledge objects submitted to a particular topic Inbox. These editors have the authority to either accept or reject knowledge objects, or forward them to a more appropriate topic. They can edit, move or de-link knowledge object metadata within the topic area, as well as suggest additional links between knowledge objects within a topic and other related topics.

There are several reasons listed as attractive for future editors including seeing first hand the cutting edge knowledge and information submitted and raising your profile in the global research community by displaying a biography (and photo) online. Despite the seemingly large workload for the topic editor, there are about twenty subject experts that are currently working on content submitted to the oneFish repository. Similar reasons are listed, together with altruistic reasons, for the participants in the open-source developers community (Hars & Ou, 2002).

We will discuss detailed design principles for the Knowledge Portals in the next part of this paper.

2.1 Design principles for Knowledge Portals

There are certain design principals that should be addressed when building virtual communities, like research communities, online. Some of these principles are general principles of social computing and interaction that should be taken into account when designing online collaborative spaces and others are specific to the development of online research communities.

2.1.1 Designing for social interaction

Kollock (1998) emphasizes the following three general design principles for community building, based on the principles of social interaction and collaboration. These principles are derived from the so-called "Prisoner's Dilemma" situation and its study by Axelrod (1984). Axelrod at that time was writing requirements for the possibility of cooperation between people in general and did not considering virtual teams. These three principles of cooperation, according to Axelrod (1984) are:

1 Arrange that individuals meet each other again
2 Individuals must be able to recognize each other
3 Individuals must have information about how the other has behaved in the past

When designing online spaces for virtual communities of practice, the first principle translates into the fact that it must be likely for the individuals participating in virtual collaboration to be able to meet in the same place in the future. This means that in order to be successful, communities should promote ongoing interaction of community members by designing forums as discussion spaces for community members.

The recognizeability principle is also quite important for the virtual community of practice – this means that the individuals participating in collaboration should be able to find out some information about each other. It is interesting that this principle often is in direct conflict with the ease of anonymity on the Web. The recognizability principle supports group sociability that is influenced by knowing who

is participating (Turoff et al., 1993). It is also instrumental in combating online interaction resistance issues by promoting trust as " an individual's ability to feel comfortable with the Web site/online community owner's ability to protect users' personal safety and privacy…" (Andrews et al., 2002).

The third principle is that the history of the individual's behavior in the past should be known. When information about the individual and all actions of this individual is collected within the Virtual Community, there is a reputation development process that encourages accumulation of social information and trust within the group.

The importance of accumulating knowledge about the individual members in the Virtual Community is also emphasized by Godwin (1994). He suggests that online communities should be designed to provide "institutional memory" that tracks group history and events. This "institutional memory" helps to promote continuity, keeping the "same faces", knowing personalities and reputations and having ongoing relationships – in turn supporting the first principle of collaboration in virtual communities.

2.1.2 Designing for collaborative work

In addition, Kollock (1998) extended the above general human collaboration principles to online communities of practice involved in cooperative work and collective action based on Ostrom's work (Ostrom, 1990) on the communities acting together and on some general requirements of this collaborative work. The most prominent principles are that the rules governing the use of collective goods should be matched to local needs and conditions and that most individuals affected by the rules can have a role in modifying these rules. This should translate into design flexibility for the Virtual Collaborative Environments, where the interface could be easily customized based on the member's needs or preferences.

We believe that the most important design consideration for the Knowledge Portals would be to have a common "artifact" or a set of artifacts that the community is collaborating on. This should be a part of the Virtual Laboratory work. These artifacts could be industry databases, collaborative documents or collaborative reports.

In the resent study on the communities of practice in a distributed environment and on the use of a document as a shared artifact for communicating and sharing knowledge between the members of the virtual community (Kimble et al., 2001), it was found that joint work on the shared document within the virtual collaboration group brings a stimulating quality into the collaboration process. This shared document not only stimulates discussions between the members of the group, but also acts as a catalyst for collaboration, thus creating a supportive environment for continuity of the Virtual Community.

2.2 Technological solutions for knowledge collaboration

In this part of the paper we will describe existing technological solutions already adapted by virtual communities of practice for maintaining corporate knowledge portals and scientific publishing and knowledge exchange spaces.

2.2.1 Corporate knowledge portal

Corporate knowledge portals are the single point access software systems that are designed to provide timely access to information and to support communities of corporate knowledge workers. All documents produced by the portal users are deposited into a repository. These documents undergo a variety of knowledge and content management processes.

For example, there are two types of the knowledge management processes in the IBM's Global services knowledge portal (Mack et al., 2001). Firstly, there are higher-level knowledge management processes that involve dedicated teams of content experts that evaluate the quality of materials submitted into the repository. This might include review, classification and even certification of the documents submitted into the repository by teams of experts.

As a second level of content management, documents submitted into the repository are automatically gathered, registered, managed and even analyzed. A "crawler" technology supported by the content analyzer that extracts text and meta-data from each document is used to aggregate electronic information.

The extracted component is presented in a standard XML format that allows text analysis and indexing processes in order to cluster and categorize the document in the repository. This also helps to create a centralized search index for a collection of documents in the repository. Moreover, often in order to facilitate the use of documents in the repository a subsequent analysis is used to analyze the document content using linguistic analysis and extracts the domain-specific features of the documents that help in clustering of the documents. The analysis process is performed semi-automatically, under the supervision and control of the portal administrator that has the power to exclude certain types of documents from the automatic clustering process. At the end of the clustering process taxonomy for the knowledge portal is developed. A document categorization operation is performed when new documents are added to the portal. The document categorization system assigns documents to the categories that represent nodes in the portal taxonomy.

The quality control, by a team of experts, of documents submitted into the repository increases the value of the portal assets but could be a "bottle-

neck" in getting the information into the repository in a timely manner. There are some compromises in maintaining the quality of documents while doing this automatically, as an example click logs can be used to find out how many times the document was accessed and machine learning will be used to detect useless documents.

2.2.2 Scientific publishing and information exchange portal

A similar approach is taken by the IST Fifth Framework funded SciX (Open, Self Organizing Repository for Scientific Information Exchange) Project (Gudnason et al., 2002). SciX project aims to demonstrate new business models for scientific publishing and develops Web services for scientific publishing and information exchange.

The service provided by SciX has three main components such as the repository, the virtual community and the e-Journal. SciX is using machine learning and clustering techniques to manage the repository with minimum human intervention to provide for a sustainable system. The virtual community is designed to enable the users to exchange scientific information, knowledge, educate themselves and find people with similar interests. eJournals permit publication of submitted and reviewed papers.

We found that the most important feature of the SciX system is the ability to provide so-called value-added "wrapper services" to the users. These "for fee" services allow wrapping content in the repository in a way that is more appealing for industrial companies.

The value-added services fulfill a very important need for the AEC companies – they present research information in an easy to understand and easy to use format for companies that have no time and resources to go through conference proceedings and journal papers, event if these papers are easily accessible via e-Journals. The processing of knowledge in the repository into value-added products for the industry is done by "knowledge workers". They are the new actors in the value chain of the electronic publishing process. The concept of value added services is quite important; it brings up a new model of electronic publishing, which is totally different from the old paper-based publishing model by the virtue of facilitating new knowledge creation and aiding in technology transfer to the industry.

We believe that the same concept could be extended to the creation of value-added services not only to the industrial partners, but also to the scientific community by aggregating research data and creating new scientific knowledge based on research results submitted to the repository by members of the virtual community of practice. This new aggregated and structured data will be a part of the Virtual Laboratory of the Knowledge Portal and will be instrumental in the knowledge creation process.

To achieve this, the virtual community will need to attract highly skilled content experts as "knowledge workers" that would be able to extract information contained in different research studies and aggregate it into new knowledge. Further in the paper we will give an example of the virtual community of practice with the added value research service. This also could be achieved by involving virtual community members into joint creation of new knowledge by participating in the creation of a common document, knowledgebase, or in general a "knowledge artifact".

3 FUTURE APPLICATION FOR THE KNOWLEDGE PORTAL MODEL

In this part of the paper we will describe the application of the Knowledge Portal model to the research and practice area of Lightweight Aggregate and Lightweight concrete production. The Lightweight Aggregate Producers association, in order to create the Lightweight Concrete Knowledge Portal, contacted the authors of this paper, and this is the first, conceptual part of the work.

3.1 Lightweight Concrete virtual community

To evaluate the current state of information dissemination in the area of lightweight concrete, the authors of this paper thoroughly researched online resources on lightweight concrete and found only few available (Kondratova & Goldfarb, 2003). The most comprehensive source of information on lightweight concrete and, particularly, on structural lightweight concrete found was a Web site of the Expanded Shale, Clay & Slate Institute - ESCSI (2002). The ESCSI site provides detailed information on structural lightweight concrete; lightweight concrete aggregates, national and international companies-members, and has links to some comprehensive state-of-the-art reports and publications on the long-term performance of lightweight concrete (Holm & Bremner, 2000; Holm & Ries, 2001).

However, we found that even this most comprehensive of existing online resources on lightweight concrete lacks the depth and breadth of coverage of the topic. For a person seeking information on lightweight concrete, be it a homeowner, a concrete researchers, or a representative from the industry, it would be beneficial to have a "one stop" complete information source on production, properties, use, and environmental advantages of lightweight concrete – a Lightweight Concrete Portal. This Portal will contain a Repository of scientific reports, research papers, a Discussion Forum for researchers and industry practitioners and a Virtual Laboratory that contains structured testing data for lightweight concrete and lightweight aggregates.

3.2 Lightweight Concrete Knowledge Portal

The proposed Knowledge Portal for the industry will include a Discussion Forum with a comprehensive search and retrieval capability and a supporting Repository of scientific information in the form of technical reports, publications, product specifications, etc. with an advanced indexing, categorization, search and retrieval tools.

Over the years, the model of communications, using a data repository and a discussion forum for information exchange, has become a popular choice for IT industry, including the open source software development community (World Wide Web Consortium, 2002) and technology consumer products Web sites (Digital Photography Review, 2002). We believe that it could also, potentially, bring significant benefits in the area of scientific information dissemination and exchange.

However, the repository by itself will not be able to support forum discussions without the value-added services provided by the Virtual Laboratory. The state of the art reports, document summaries, and industry databases maintained by the knowledge workers in the Virtual Laboratory should provide the necessary support and structured materials for the forum discussion participants to quickly retrieve information related to a particular discussion topic in order to support effective participation in the discussion.

In the case of the Lightweight Concrete Knowledge Portal, the existing industry databases, such as the CANMET database for the environmentally friendly concrete (Kondratova et al., 1998) and the Natural Weathering Exposure Station Treat Island Web site for the US Army Corps of Engineers (USACE, 2001) containing long term testing results should become a part of the Virtual Laboratory (Fig.2).

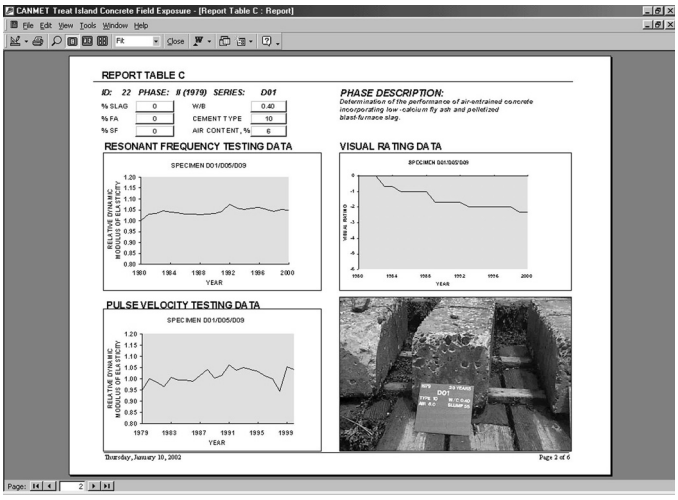

Figure 2. CANMET database: nondestructive testing and visual evaluation report

The Virtual Laboratory model will help to maintain an environment of a "live" and dynamic scientific forum, where scientists will exchange information about new projects and research directions, get peer reviews of their research data and publications, and get valuable feedback from the industry. On the other hand, users from the industry would be able to follow the "cutting edge" research directions, and to receive answers to their questions from worldwide experts in the field.

4 CONCLUSIONS

The authors believe that the proposed model of the scientific Knowledge Portal could be applied not just for a particular case of the Lightweight Concrete Portal, but also could serve as a generic model for the design of the Virtual Research Collaborative Environments. This paper emphasizes the importance of certain design considerations for these virtual environments such as providing a Discussion Forum and a Virtual Laboratory supported by a comprehensive range of value-added services supplied by content experts.

In order for a Knowledge Portal to become a valuable tool for researchers and industry practitioners that allows better utilization of existing knowledge and new knowledge creation, the Portal Repository, Discussion Forum and the Virtual Laboratory should be equipped with advanced search and information retrieval capabilities that are needed to support fruitful discussions.

Knowledge utilization in this case includes technology transfer, information dissemination and utilization, research utilization, innovation, and organizational change (Backer, 1993) and, according to Paisley's research (1993) "Digital technology brings the most significant new communication capabilities to knowledge utilization…"

The task of achieving a sustainable pattern of growth for the construction industry is tremendous (Mehta, 2001), but it could be accomplished by making an industry-wide paradigm shift to the culture of conservation of energy and materials. This paradigm shift should be supported by another shift related to the use of information technology to utilize knowledge on sustainable construction materials.

One of the proposed steps in utilizing the power of the Internet to facilitate knowledge exchange and new knowledge creation on environmentally friendly materials is to set up an International Lightweight Concrete Knowledge Portal. This portal could be based on an existing industry association Web site, for example the ESCSI site that already incorporates some essential attributes of a vertical industry Web Portal such as links to scientific information and to an industry forum.

According to research studies (Newell, 1998; Turk et al., 2002), professional associations have great po-

tential to play a mediating role in the diffusion of knowledge. They provide a forum for the creation of inter-organizational networks that, in turn, create the necessary channels for diffusion of information, knowledge and ideas that enable companies and organizations to bring technological innovation. However, individual members of the professional association can benefit from these opportunities only if they attend workshops, branch meetings, etc, which can be costly and time consuming.

Internet technology is removing these barriers. With a development of a full scale Knowledge Portal, ESCSI, as an international industry association, could become a worldwide source of credible information, knowledge and expertise in the area of lightweight concrete and will be in a position to directly influence innovation and technology transfer to the industry. A comprehensive Lightweight Concrete Knowledge Portal, containing a repository of scientific knowledge, a Discussion Forum and a Virtual Laboratory with the testing data will also provide unique collaborative work and e-learning opportunities.

The model of scientific communication in this case will come closer to the modern scientific communication model (Hurd, 2000). The most important feature in this new communication model, discounting modernized technology that supports traditional publishing functions and the e-publishing process, is to include repositories of raw data on Internet servers, for use by researchers that wish to build on findings of others, or to create new knowledge by combining their own data with the data of others.

The proposed Lightweight Concrete Knowledge Portal will be based on this model. Some information on the Portal could be provided free of charge and some value-added services will be for members and subscribers only, similar to the model adapted by the highly successful CorrosionSource.com Web Portal that contains a knowledgebase of corrosion protection resources and a popular Discussion Forum for corrosion community (McHugh, 2002; Corrosion Source, 2003) and by the SciX Digital Library (SciX, 2003). The proposed model of an online collaborative environment would also provide new opportunities for distance education of graduate students and young researchers (NRC, 2001), and create a valuable communication and collaboration channel between private companies and researchers.

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