COLLABORATIVE DESIGN OF A GLOBAL SUSTAINABILITY KNOWLEDGE NETWORK FOR ENGINEERS

D F Radcliffe, N Clark

Abstract

Sustainability, in all its meanings, is becoming increasingly important in design engineering. However much of the relevant information is dispersed or difficult to locate as it is generated by experts in many discipline areas not just in the conventional engineering ones. Indeed, the whole question of sustainability is multi-disciplinary in nature. To meet the needs of practitioners, researchers and students in this area, a web portal has been developed, the Sustainability Knowledge Network (SKN). The SKN contains 4000 resources and has other value adding services for its users. While its origins were as a subject gateway, the Australian Virtual Engineering Library (AVEL), the SKN is evolving into a portal based on a broker model that will facilitate greater interaction and exchange between users. The SKN is the inaugural element of a global Virtual Environment and Sustainable Systems Engineering Library (VESSEL). AVEL and SKN were developed by a national consortium of partner organisations including universities, research organisations and engineering institutions, that were geographically dispersed. The successful development of these resources involved the close collaboration of engineers and librarians working as a distributed virtual team. Another success factor was the focus on capturing the continuously changing user requirements.

Keywords: sustainable design, knowledge portals, subject gateways, virtual library,

1. Introduction

Sustainability is central to engineering in general and design engineering in particular. It is not a new issue but its significance has been increasing with the growing awareness in industry of concepts like the triple bottom line and espoused policies of professional engineering institutions globally [1]. Engineered products, systems and infrastructure must not only be technically sound and cost effective, but also sustainable in both the ecological and the social sense. This demands innovation that builds upon "good" engineering and emerging technologies and which incorporate ecological and societal factors systemically.

There is a global demand for high quality information on engineering and the technological aspects of sustainable development, especially via the WWW. However, the relevant information sources are dispersed across many discipline areas and are not easy to locate and assemble. Practitioners, academics and students in engineering and related fields are not always aware of what networked information is available. They are sometimes confused about various resources and have difficulty in finding relevant resources. The sheer volume of information on the web is staggering. In 2002, the number of Web pages exceeded the number of people available to read them. In January 2003, Google invited Web surfers to search over 3.1 billion Web pages, while NetNames gave a figure of over 36 billion for total domains registered worldwide in the previous year.

To address these needs, a Sustainability Knowledge Network was established to bring people and information together around the overlapping themes of engineering, new technologies and the sustainability imperative as they impact on a diverse range of industry sectors and community interests. This portal is a "middle-ware" agent, sitting between the user and the web, helping people discover relevant resources and delivering them in a usable format. The "value-add" comes from the human expertise and judgment in the selection of resources and the creation of metadata records. This paper describes and analyses the issues involved in creating a sustainability portal through the active collaboration of domain knowledge experts (in this case sustainability and engineering) and the expertise in information management available in university libraries.

2. Building a Foundation - the Australian Virtual Engineering Library

The Australasian Virtual Engineering Library (AVEL) was established in 1999 as part of a wider movement in Australia which has focused on developing discipline -specific, subject gateways in order to assist with the delivery and dissemination of academic information. In Australia, this movement is coordinated by the Australian Subject Gateways Forum.

The initial development of AVEL was funded through the Research Infrastructure and Equipment Scheme of the Australian Research Council (ARC) and contributions, cash and in-kind, from a national consortium of partner organisations. The foundation partners were the University of Queensland, Queensland University of Technology, the University of NSW, the University of Melbourne, Monash University, the Institution of Engineers, Australia, Distributed Systems Technology Centre and the CRC for Mining Technology and Equipment. The project commenced in February 1999.

AVEL was designed as a gateway to quality web resources. This is achieved by having experts select resources for inclusion and by maintaining the information management disciplines of librarians, including the use of widely available thesaurus for terms, clearly developed and articulated resource selection criteria and consistency in the quality of record creation. The AVEL database contains records describing WWW resources selected for their relevance. This information is called metadata and includes both a summary of the resource, created by a librarian, and information pertaining to the location, creation and so forth for the original resource. By searching or browsing the AVEL metadata, a user can either link to that resource or extract relevant metadata. Links are regularly checked and information is updated. AVEL does not contain sources found only by trawling the WWW with an automatic robot, as is the case in other repositories. However, the quality assurance through the involvement of people in creating and maintaining the database is resource intensive.

Given the geographical dispersion of the project partners, the AVEL project was managed as a "virtual team". The core leadership team was based at the University of Queensland and did much of the day-to-day management. A local management group meets monthly to review progress and plan. Their documents were shared with the more geographically remote partners. An annual partners meeting is also held. Achieving a level of transparency and visibility was a key enabling strategy, made possible through an evolving Web page. The members of this "virtual team" can enter records using a web-based metadata entry tool. This enables them to complete their contributions to the project anywhere at anytime. A project web site was created from the beginning of AVEL. This contains all the policy documents for the metadata schema, the selection criteria and instructions on how to enter metadata, the thesaurus schema and areas of responsibility for all partners.

Within 18 months, AVEL held over 2000 records, more than comparable with other global subject gateways given the Australasian focus of the collection. Resource types included web sites, conference announcements, and full text articles,

3. Evolution of the Sustainability Knowledge Network

3.1 AVEL-SD

In early 2000, the concept of a gateway focused on Sustainable Development related to engineering was proposed by the core AVEL team and the Institution of Engineers, Australia. To avoid deflecting the core mission of AVEL, or trying to create a whole new gateway, a strategy emerged to establish AVEL-SD (AVEL-Sustainable Development) as a sub-site within the overall AVEL gateway. This allowed some sharing of resources without compromising the original AVEL. It was to be a prototype to explore a number of issues.

The AVEL-SD consortium was based on the original partner organisations, albeit with additional inputs from several of these especially the Institution of Engineers, Australia (IE Aust), the University of Queensland Library and the Distributed Systems Technology Centre (DSTC). Working closely with the IE Aust., the Institute of Professional Engineers, New Zealand (IPENZ) joined the consortium and both provided links to the World Federation of Engineering Organisations (WFEO) and United Nations Educational, Scientific and Cultural Organisation (UNESCO). Having both the peak professional bodies for engineering in Australia and NZ involved was indicative of the increased recognition of sustainable development and sustainability issues to professional practice. IE Aust accredits all engineering courses in Australia and an awareness of the principles of sustainable development is one of the core attributes that graduates are expected to possess.

A basic business plan was developed to cover issues such as collection development and resource selection were resolved including access to materials from IE Aust and IPENZ from their environmental engineering and sustainability groups. While the trial was successful and considerable interest was raised, it was difficult to sustain both AVEL and AVEL-SD. During 2002 the Australasian Virtual Engineering Library decided to re-focus its content, redesign the user interface and strategically re-align itself to be more in keeping with this move towards incorporating sustainability principles into mainstream engineering practice.

3.2 Sustainable Knowledge Network

The AVEL - Sustainability Knowledge Network was envisaged as something more than a subject gateway or portal - a virtual place for engineers and others to "meet" and share information in many forms and media. The scope is not solely on sustainability, but the network also incorporates information on developments in core engineering disciplines (mechanical, civil, etc.), and developments in new technologies and innovations (but not just IT). This clearly reflects the AVEL origins. It has the benefit of not isolating sustainability as something new or different, but rather as part of the emerging spectrum of engineering.

The initial stage of the redevelopment has seen the development of a new web site hosted at the old AVEL domain name, as well as the migration of existing key resources already contained within the AVEL repository and the addition of new resources that focus on sustainability. In response to customer feedback the emphasis is on building a collection of freely available and reliable full-text content. Full-text papers from the Environmental Engineers Society (IEAust), CSIRO and the Academy of Science Technology and

Engineering have been made available to AVEL for hosting. The existing metadata management software (HotMeta from DSTC) was upgraded during this time. The Sustainability Knowledge Network went live in September 2002. By the end of the year there had been a 17% increase in traffic to the domain, and a 75% increase over the previous 12 months.
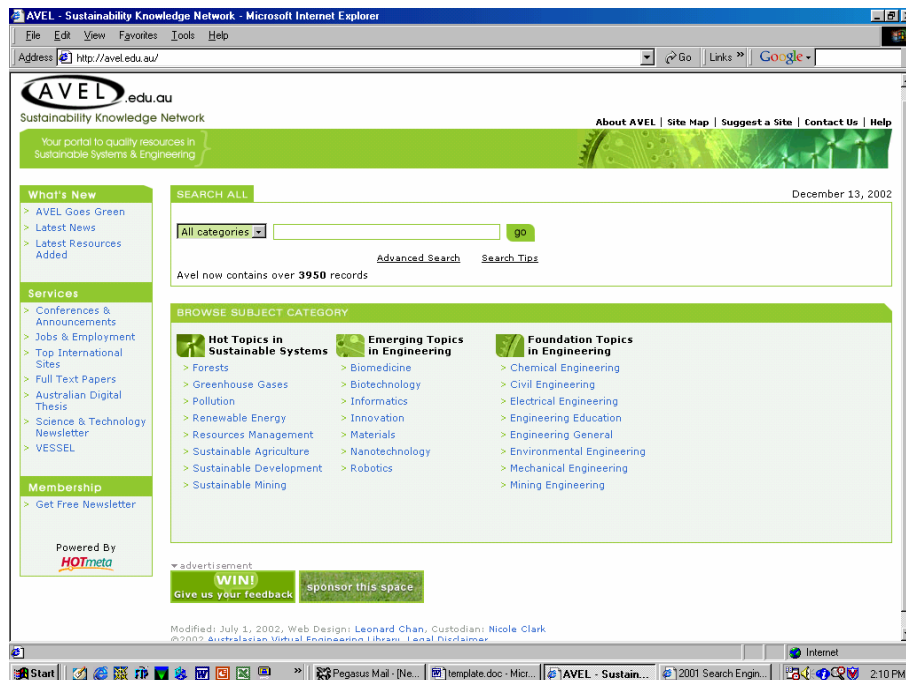

Figure 1: Sustainability Knowledge Network Homepage (avel.edu.au)

For the purposes of browsing the resources are organised into overlapping themes on the home page - Foundation Topics in Engineering, Emerging Topics in Engineering and Hot Topics in Sustainable Systems. The Foundation Topics are grouped by traditional discipline areas, i.e. chemical engineering, civil engineering and so on. The Emerging Topics include biomedicine, biotechnology, informatics, innovation, materials, nanotechnology and robotics. The Sustainable Systems section is very broad and includes forests, greenhouse gases, pollution, renewable energy, resources management, sustainable agriculture, sustainable development and sustainable mining.

The second phase of the website redevelopment which is underway will see the trial installation of metadata harvesting software. If successful this will allow the Sustainability Knowledge Network collection to be rapidly expanded. The vision is to give the user the option of choosing only humanly evaluated records, or automatically harvested records. Project partners will also have the opportunity to use HotMeta 2.0 software to directly enter metadata which adheres to the project's metadata schema into their existing web page. This will enable more accurate harvesting to occur as well as save partners time in creating separate metadata descriptions. Increasingly, subject gateways are realising that hand-created metadata is an expensive process that cannot be supported on a stand-alone basis. A metadata record for an average website can take between 20 and 30 minutes to create. While these records are of great value in assisting resource discovery, they must be supplemented with viable, longer-term solutions.

The third phase will enable services which promote collaboration and knowledge exchange to be added to the gateway. The types of services and functions offered by the Sustainable Knowledge Network include:

Table 1 AVEL-SKN Features

Feature	Purpose
Searchable database with access to full text publications	• *Access to full-text publications such as technical reports and conference papers from partners* • *Intellectual Property rights for each document captured in metadata schema*
Expertise Directory	• *A searchable and browseable online directory to facilitate multi-disciplinary knowledge transfer and partnerships*
Topic based discussion forums	• *Regular moderated discussion forums which will showcase research*
Searchable, browseable, metadata enabled links	• *Central repository of metadata enhanced WWW resources*
Conference / Events Listings	• *Centralised discovery of conferences and events as well as user-submitted events listings*
Online News	• *Links to current news in the area of sustainability*
Bulletin Board for News Postings	• *Topic-based bulletin board postings to facilitate communication and knowledge sharing*

Thus the Sustainability Knowledge Network is becoming a web space that will allow users to interact, exchange information and collaborate using a broker model. But it is also part of an ambitious global project to provide web resources on sustainability and other services to practitioners, researcher and students everywhere.

4. VESSEL - a Global Sustainability Resource

Through the collaboration with IE Aust., and IPENZ, the Sustainability Knowledge Network is the inaugural part of a global set of resources in sustainability related to engineering VESSEL or the Virtual Environment and Sustainable Systems in Engineering Library. VESSEL is a joint project between the Sustainability Knowledge Network and the World Federation of Engineering (WFEO). WFEO represents the world-wide engineering profession through over 80 national members, and nine international members representing regional groupings. In partnership with UATI it forms the International Council for Engineering and Technology (ICET), an umbrella organisation associated with UNESCO [2]

The principal emphasis of the VESSEL network will be to provide developing nations with improved access to resources that can assist in education in science, technology and engineering, at senior levels in schools and technical colleges and universities. The network will aim particularly to provide resources to teachers and lecturers, and will seek to meet the requirements identified within the developing countries.

Each of the member nations of the World Federation of Engineering Organizations (WFEO) and of the International Union of Technical Associations (UATI), will be asked to become a supplier of material, or a user and definer of needs. It is anticipated that the world-wide network they establish will be a substantial aid to international sustainable development. Each of the WFEO members plan to establish national and international committees drawn from the Science, Engineering and Technology communities in order to assemble appropriate resources/documents in their virtual library collections, with the aim of providing free access to students, and those entering practice in these disciplines, around the world. [2]

5. Lessons and Challenges

One of the strengths of AVEL and now AVEL-SKN is that it has continued to sustain and develop collaborative relationships between geographically dispersed partners. This and a focus on the end users and other stakeholders have yielded some lessons for the development of similar resource gateways that are inter-disciplinary in nature.

5.1 Library and Engineering Partnerships

AVEL succeeded in gaining the support of the engineering community from the beginning of its existence. It was recognised from the start that the survival and success of an engineering subject gateway would not be possible without the support and involvement of its target audience. The involvement from the outset of both engineers and librarians in the creation AVEL in a unique collaboration has been a critical success factor. The role of the IEAust has been very important, not only because of their financial support but more importantly for the conduct they provide to the wider engineering profession.

The target user community has been encouraged to provide input and define the way AVEL evolves. Decisions concerning the choice of thesaurus, metadata schema, interface, keyword searching, resource selection policy, target audience and others were made with input from both engineers and librarians.

Some of the strategies employed to foster collaboration and communication have included:

- workshops and presentations to key engineering groups;
- presentations and reports to the Australian Council of Engineering Deans;
- presentations to engineering faculties, schools and departments in universities;
- inclusion of news about AVEL in engineering publications;
- links to AVEL from many other engineering websites.

5.2 Know your Users

Another obvious lesson has been to the absolute need to understand the user requirements. AVEL evolved rapidly to provide not only a virtual library, but also a suite of virtual information services for engineers that mirrors the way they source information. Ellis and Haugan [3] conducted a study on information seeking patterns of engineers and research scientists in an industrial environment. They found that personal knowledge networks are crucial to the way engineers utilise information:

> "*When the engineers were confronted with a subject unfamiliar to them, they tended first to look for colleagues or other contacts within their personal network who possessed the knowledge......The engineers chose their information channels based on their own experience and knowledge through the consultation of personal contacts, or both methods*."

However, information overload has become a real issue for engineers. As engineering discipline moves towards linking with inter-disciplinary areas, both problem solving and keeping current are becoming difficult. Many engineers are now working in areas with environmental, social, biological, health, economical, financial, political and technology implications. Relying on one's personal networks and colleagues will cease to be sufficient in the long term.

Customer expectations of gateway services as well as their information needs are dynamic. Discovering and responding to these needs has been crucial to the AVEL-SKN strategic plan and to the evolution of AVEL's services. To be successful, the innovative gateway needs to identify these needs and tailor their services to meet them. They also need to continuously monitor customer demands and react accordingly by adapting or adding new services and information resources as required. In order to identify, anticipate and fulfill the needs of our audience we have employed a number of strategies and undertaken a range of qualitative and quantitative research. Some of these methods are detailed below.

Focus group sessions with academic staff and postgraduate students from two of the Partners were held to determine the information seeking needs of the target audience of AVEL and then accommodate these needs within AVEL. The respondents stated the importance of locating expertise and contact information for colleagues. They claimed that a critical component of engineering research was keeping up-to-date with breakthroughs and the discoveries of groups undertaking similar research.

Participants were asked to describe the type of information they looked for on the Web. Were they interested in finding information on a broad topic, or on a specific problem? Did they require the expertise of a colleague or were they looking for free full-text information? Not surprisingly, the responses indicated that users look for value-added features that distinguish AVEL from its rivals, especially from the larger, established search engines such as Yahoo and Google. Respondents echoed established research, which suggests that engineers primarily use personal networks and contacts to seek and exchange information.

Specific questions were asked about the browsing function. Was it used, and how was it used? How could it be improved? The need to implement a browse option that had a close "fit" to the information seeking behaviours of our users was seen as crucial. In response to suggestions made by focus group members we made a number of significant changes to the browse structure and presentation.

Another method of used to measure the ways users currently use AVEL was an online survey. The survey was put on the AVEL Website, and was also distributed to subscribers of the AVEL newsletter. The survey focussed on gathering basic demographic information, current service usage and customer satisfaction with current services as well as identifying the types of services respondents would like to see added in the future.

When asked what services they were currently using, full text access and current awareness services featured strongly. 21% of respondents said they used full text papers, 20% used the newsletter, and 14% used the "Latest Resources" feature of AVEL. Other services such as the "Online Bookshop" and the "Conference Announcements" section received an 8 - 10% score.

In terms of future services, the majority of respondents echoed the desire for full text information and current awareness services. Most said that "Links to Electronic Journals" (21%) or an "Alerting Service" (20%) were features that they would like to see added. 13% favoured an "Expertise Directory" while 12% each wanted to see "Online Seminars by Experts" or an "Ask and Expert Service".

Other methods used to continuously evaluate the utility and effectiveness of SKN include analysis of suggestions and comments to the AVEL site, the number and variety of subscribers to the newsletter, the website usage statistics in terms of numbers, trends over time and location of users.

5.3 Sustaining a AVEL-SKN

Not only is the Sustainability Knowledge Network a meta-source for resources on sustainability and engineering, it also faces some challenges in terms of its operational sustainability. The first generations of subject gateways were an evolutionary or adaptive response to what was perceived in the mid 1990's as the growing dysfunction or anarchy of the Web. Subject gateways were an obvious solution to this information explosion.

However the next generation search engines such as Google and All The Web go beyond indexing only HTML pages and can recover more of the "deep web" (such as PDF and image files) than was previously accessible. Their search algorithms also mean that more relevant search results are returned. In order to retain their role as a vital human intermediary, gateways have had to adapt and refine the services they offer. Gateways have evolved in new ways in order to save their users time in searching and to deliver them the content and services that they require.

The "deep web" remains a very real obstacle to researchers accessing the high quality information, despite inroads made by search engines. In an online user survey conducted by AVEL in 2001 72% of respondents said that finding full-text resources was important to them. By "surfacing" these resources gateways provide a significant value-added service to their users. Facilitating collaboration and knowledge exchange between members of their user community is another way that gateways are distinguishing themselves from other web search tools and this will be discussed more below.

Another, possibly more pressing driver of change for subject gateways is their user group. Research has suggested that the gateway concept alone will not satisfy the demands of savvy researchers in the future. The results of focus groups and an online survey conducted by AVEL echo what has long been established in the literature about the information seeking habits of those working in engineering, science and technology. Researchers use the Web not only to find information but also to "to maintain their identity, to engage in discussion and to circulate information"[4].

One of the major challenges for information providers at the moment is offering integrated access to this growing range of distributed and heterogeneous information resources and services. There is research underway in Europe on new broker architectures [5] including the Renardus project [6]. Such technology is, however, expensive and AVEL is exploring more cost effective alternatives and partnership opportunities that may facilitate this type of cross-sectorial information exchange.

6. Future Work

In addition to continuing to grow the resources base and extend value adding services to our clients through initiatives like VESSEL, there are a number of issues around how engineers and others use SKN that we plan to investigate. As engineers seem to rely upon "trusted" sources - like colleagues and tested information sources and informal networks, our aim is to provide a virtual equivalent of these trusted sources. Future developments will reflect this through the introduction and testing of interactive information exchange from users (similar to bulletin boards), access to expertise directories and the like. We are planning to conduct additional usability testing using an instrumented usability lab, to extend our earlier heuristic evaluation of user issues. On the technical side, we will be evaluating developments in web technology such as the OAI initiative [7] and new web services architectures to accelerate the transition to a broker model of operation.

7. Acknowledgments

References

[1] Ellis, M.D. "The Role of Engineering in Sustainable Development", Pub American Association of Engineering Societies , AAES, Washington. 1994

[2] Rourke, W.J. "A Vessel for Engineering Education in the Developing World", 2nd World Engineering Congress, Sarawak, Malaysia, 22-25 July 2002

[3] Ellis, D. and Haugan, M., "Modeling the information seeking patterns of engineers and research scientists in an industrial environment", Journal of Documentation, Vol 53 (4), 1997 pp384-403.

[4] Ballantyne, P. and Addison, C., "Cooperation on the Web: trends and practice in the development sector", Information Development, 16 (1), 2000, pp15 – 23

[5] Huxley, L, "Renardus: fostering collaboration between academic subject gateways in Europe," Online Information Review, Vol 25 (2), 2001, pp121-7.

[6] Renardus 2002, Renardus Homepage, [Online] Available at: http://renardus.lub.lu.se/

[7] Hussein, S. and Fox, E A, "The Open Archives Initiative: realizing simple and effective digital library interoperability," J of Library Administration, 35 (1/2), 2001, pp125-45.

For more information please contact

David Radcliffe
Catalyst Centre, School of Engineering, University of Queensland, QLD 4072, Australia,
Tel: Int +61 7 3365 4091 Fax: Int +61 7 3365 4799 E-mail: dradcliffe@thiess.com.au,
URL www.catalyst.uq.edu.au