Theme:

Title: **Empowering individuals to design and build collaborative information spaces**

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Abstract: *Web-based project management applications serve project teams and virtual enterprises to manage project information anywhere, anytime. Central to these applications is an EDMS that enables team members to store and organize all project documents, independent of type and format. We consider two problems regarding the adoption and effective utilization of such systems. Firstly, the advantages of using an EDMS become apparent only after a relatively large collection of documents has been stored and organized in the system. Secondly, EDMS's currently offer little support for searching and retrieving information that straddles various documents. In order to address both problems, we propose a number of user abilities to add to current EDMS functionalities, offering the user increased freedom in locating and placing a document within a collaborative information space. We explore these abilities at the hand of two information environments: one developed for the Swiss AEC industry, the other currently under development as a common and extensible library for design precedents' analyses.*

Keywords: *information architecture, document management, EDMS, collaboration, design analysis*

Introduction

Web-based project management applications serve project teams and virtual enterprises to manage project information anywhere, anytime. Central to these applications is an electronic document management system (EDMS) that enables team members to store and organise all project documents, independent of type and format. For this organisation, users commonly have access to a folder hierarchy, a categorisation using keywords, and explicit relationships to be specified between documents. The combination of these, if used effectively, is generally sufficient to specify an organisation that enables an efficient retrieval of individual documents of interest.

We consider two problems regarding the adoption and effective utilisation of such systems. Firstly, the advantages of using an EDMS become apparent only after a relatively large collection of documents has been stored and organised in the system, an activity that in itself seems to offer few immediate benefits. As a result, too often, an intended use of an EDMS to support a design and construction project has been abandoned due to time constraints. Secondly, EDMS's currently offer little support for searching and retrieving information that straddles various documents, without painstakingly reading and viewing each and every document that apparently fits the search criteria. While full text searches may offer some support when dealing with text-only information, the variety of document types and formats still eludes any global recognition mechanisms.

In order to address both problems, we propose the following user abilities to add to current EDMS functionalities, offering the user increased freedom in locating and placing a document within a collaborative information space:

- the ability to define multiple independent dimensions for organising and locating document entities in the information space.
- the ability to specify a (semantic) structuring of each dimension's values (or keywords) that will assist in determining which value(s) to assign to a specific entity when locating this entity in the information space.

- the ability to decompose a document into a collection of entities, hierarchically organised according to the decomposition, where each component can be independently located in the information space.
- the ability to (visually) compose a “document” from a collection of entities that are already present in the information space, maintaining all relationships to these entities.
- the ability, using graphical maps of various nature, to view an entity within its context defined both by its location and by its relationships to other entities within the information space.

We believe these abilities will empower the user to consider the embedding of a particular document within the information space more thoroughly, thereby offering the user increased feedback on his or her contribution to designing and building the collaborative information space. This empowerment may increase the perceived benefits from storing and organising documents into an information space, and offer users an added incentive for utilising a web-based EDMS to support document management within a collaborative project.

In this paper, we explore these abilities at the hand of two information environments: the first one developed as part of a common technical platform for information, communication, and collaboration within building processes in the Swiss Architecture, Engineering, and Construction (AEC) industry; the other currently under development as a multimedia learning environment to support group work and deliberation in the context of a design studio, with emphasis on its use as a common and extensible library for design precedents’ analyses.

EDMS’s and information standards

Research into construction document management can be roughly divided into two approaches [1]: a model based approach (e.g., [2]); and an integrated document management approach (e.g., [1]).

In the model based approach, all information is collected in a single integrated (product) model from which documents can be produced almost automatically through queries. Standardisation is essential in this approach; various efforts to develop semantic standards exist in this area [3] [4]. However, no results have yet been widely implemented in practice. One of the reasons for this may be that all parties involved in a project must concur to use the established organisational model from the very onset of the project. Furthermore, because of the very detailed structure and the complexity of such models, and their general lack of flexibility, their adoption in the AEC industry is currently difficult to achieve [4].

The integrated document management approach is essentially document-based, treating the individual documents as objects that are organised and related according to various attributes. The purpose is to offer a flexible organisational framework and enable an easy retrieval of documents. The commonly used web-based EDMS’s in the AEC industry belong to this group.

EDMS’s include functionality that enables users to directly manipulate documents, index and store documents for subsequent retrieval, communicate through the exchange of documents, collaborate around documents, and model and automate the flow of documents [5]. Documents are generally indexed (manually or automatically) such that each document is associated with a set of keywords. Document retrieval is then performed by matching on the associated keywords, or through a full text search. Advanced systems implement automatic text analysers that use natural language processing for the purpose of answering questions related to the text, rather than allowing only Boolean matching queries.

In the advance of document management research, document standardisation efforts take an integral part. Problems of meaningful communication and information exchange among applications have brought up the need for document standardisation. SGML (Standard Generalised Mark-up Language) and, more recently, XML (eXtended Mark-up Language) have been adopted as standard by numerous branches of the industry for defining and representing structured documents, including the AEC industry (an overview with respect to XML can be found at [6]). While SGML is mostly used for technical documentation, XML’s use is more widespread, for data exchange, information representation on the web, etc. As a meta-language, XML serves to define mark-up languages for specific purposes. Such a language can be shared among users active in a same discipline and serve as a standard way of organising data within this discipline. The XML structure ensures that the data is consistently organised and is both machine- and human-readable.

A case from practice

For all of their potential advantages, web-based EDMS's still aren't used pervasively throughout the building industry. Various reasons and causes can be considered. Probably one of the most important obstacles to a faster adoption of such systems is the observed need to match the costs of the adoption and familiarisation of the system with the immediate profits in terms of usability and time. However, EDMS's are primarily conceived and designed in order to facilitate the efficient retrieval of documents from a relatively large collection of these. Hereto, each of these documents first needs to be stored and organised in the system, an activity that in itself offers few immediate benefits. Other potential benefits from an efficient access to such an information space, such as a more effective decision-making process or a reduction of the project's design and construction errors, are to be felt even later in the document management process.

In the case of an information, communication, and collaboration (ICC) environment for the Swiss AEC industry [7] [8], the project's industry partners, consisting of two professional organisations of architects and engineers and a number of small and medium-sized companies in the Swiss AEC industry, were very enthusiastic about the environment and its adoption into practice. At the same time, the fragmented and conservative nature of the AEC industry (in Switzerland) formed a serious obstacle to any practical use. The very essence of the environment, its support for collaboration, proved to be a hindrance to its adoption at the same time. Although the environment had been designed from the very onset keeping in mind that not all collaborative partners may choose to participate, the environment's success still hinged on a concerted adoption by a number of partners. Furthermore, time constraints and delays that are all too common in construction projects obstructed the learning and adoption of new technology.

Nevertheless, the adoption of such an environment, even if used only for data sharing and information gathering, yields clear advantages in time and information access. Time constraints and a lack of information can lead to errors and higher costs: a time constraint may impose the start of an activity before the necessary approval or other related information has arrived. Instead, electronic data sharing gives partners instantaneous access to published information. Therefore, it is important to increase the perceived benefits from storing and organising document into an information space, thereby offering users an added incentive for utilising a web-based EDMS to support document management within a collaborative project. A pre-selected folder hierarchy, a categorisation through keywords, and the ability to define explicit relationships, offer insufficient support to achieve such an effect. Instead, by offering the user additional freedom in locating and placing a document into an information space, this task may gain a more interesting and creative character.

A case from education

Information retrieval actions generally fit one of the following two categories. Firstly, one may want to retrieve a specific known document that resides in the repository. If the retrieval query contains one or more of the document's keywords, the retrieval will be straightforward and successful. Secondly, one may want to retrieve all documents pertaining to a certain topic, including their links to other related documents. Such an overview of relevant documents may provide the necessary information in order to answer a specific question, or to offer a solution to a project related problem. One may even need this overview in order to find out if a problem exists. Especially in the case of architectural precedent libraries, users are often interested in retrieving as much information as possible, across many different precedents, on a particular topic or design aspect.

The study of precedents plays an important role in architectural design and education [9]. While practitioners can rely on their own and colleagues' experience in the process of a new design, students can only draw upon documented examples of success and failure. Especially in the early stages of design, it is common practice for architecture students to prepare case studies, gathering information about existing buildings with similar functionality to the subject of their design task. By integrating the results into a common and extensible library of design precedent analyses, students can draw upon other analyses for comparisons and relationships between different aspects or buildings. Numerous examples exist that present such studies as a collection of categorised and hyperlinked documents on the web (e.g., [10]).

We are developing a multimedia learning environment to support group work and deliberation. Its ultimate aim is to empower students, at their own initiative, to organise their learning activities and to collaborate with other students and instructors. For this purpose, a variety of tools, within a strongly interactive and flexible web environment, should enable students to conceive and build information structures for information management, presentation, communication, and collaboration during the learning process. Among other applications, this environment will be used in the fall semester to support the construction and presentation of a body of architectural analyses in the context of a design studio.

The students will start the studio by analysing selected precedents (historical and contemporary) of the relevant building, with respect to various criteria (composition, program, construction, context, type, etc). Documentation of these precedents will be presented to the students in the form of drawings, pictures, and texts, and will be available on the web within the same environment that the students will use for the presentation of their own analysis results, leading to a common library of precedent analyses with respect to the students' design task.

Presentation tools for architectural analyses and building project document management applications are just two examples of environments for storing and presenting design information through collections of documents of various formats. While both environments have different uses, as presentation and cooperation tool, respectively, both are concerned with the complexity of organising an information space composed of a large number of documents and their relationships. The common question is how to organise and relate these documents in order to enable effective information retrieval. Specifically, there is a need for a document organisation that enables a user to access the resulting information space independently of the individual viewpoints of its authors. Targeting a largely unfamiliar audience, the indeterminacy of viewpoints provides the possibility to anticipate individual requests. Unexpected viewpoints derived from the information can also invoke new interpretations of existing information, which in turn can lead to creative discoveries. To support this requires a flexible and extensible model for relating and integrating the various document entities.

Organisation

A document management system commonly provides for an organisation of documents with respect to categories or keywords. An appropriate organisation assists participants when searching, browsing, and managing project information. For example, the CIP (Center for Integrated Planning) cube [11] offers a three-dimensional index for the organisation of construction documents according to established practices in the Swiss AEC industry (figure 1(left)). The three dimensions in the CIP cube are phase, function, and area, corresponding, respectively, to the design and construction process steps, to a subdivision by domains of action, and to general document contents. Documents may be submitted, selected, and visualised with respect to this three-dimensional structure (figure 1(right)).

The specification of these dimensions may be left to the project team in order to reflect on the specifics of the project and the anticipated processes. In general, any number of dimensions may be chosen. The ability to define multiple independent dimensions for organising and locating document entities in the information space is crucial in providing a high-degree of flexibility in organising the collaborative structure, while maintaining some of the rigour of an imposed organisational structure.

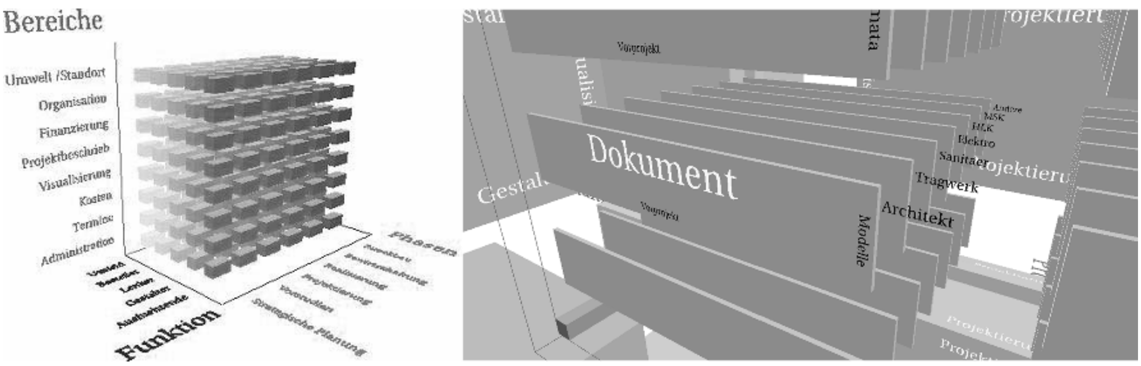

Figure 1. The CIP cube: left, overview of the cube's dimensions; right, detail of the CIP cube with open structure. Thomas Wegmüller and Walter Schärer.

Semantic maps

Each dimension in a multi-dimensional organisation is characterised by the specification of its values (or keywords). This may be simply a list of alternatives, possibly in a particular order, such as the phases in a design and construction process. On the other hand, a more complex structuring of the dimension's values may be preferred, corresponding to a semantic organisation. Within any discipline, members commonly share a definition and classification of common concepts. This structuring of shared knowledge through common concepts gives insight into that particular discipline [12]. For example, architects generally classify building designs based on spatial and formal features, resulting in a building typology. A semantic organisation, e.g., corresponding to a typology, can be specified as a compositional structure of descriptive keywords. This structure may take various forms, e.g., it may be linear (e.g., corresponding to phases), hierarchical, or form a network (figure 2).

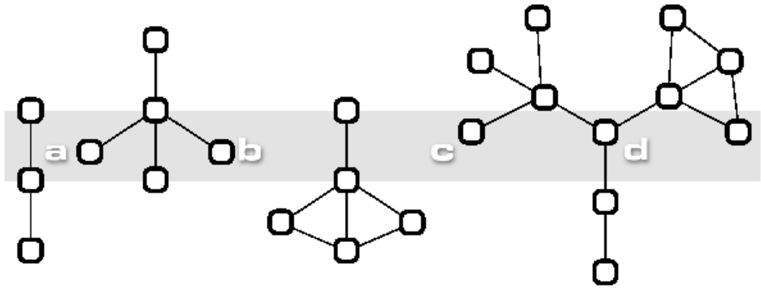

Figure 2. Schematic diagram of four different semantic structures for descriptive keywords: a) linear structure, b) hierarchical structure, c) network structure, d) combination of various structures.

The specification of a structure for a dimension's values (or keywords) assists in determining which value(s) to assign to a specific document when locating this document in the information space. Graphical visualisations of this structure support the user in interpreting it (figure 3). A semantic structure also yields a richer information structure. When keywords are organised in a structure, relationships between keywords delineate additional relationships between the documents these keywords are assigned to.

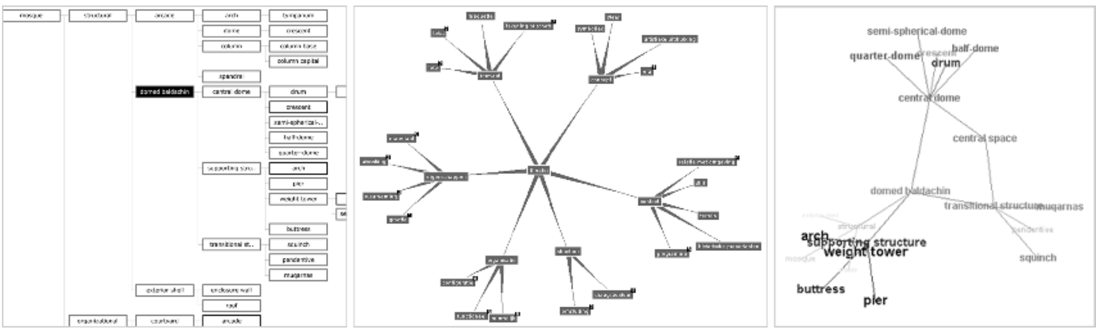

Figure 3. Snapshots from three different visualisations of a semantic structure: left, 2D list view; middle, 2D dynamic tree view; right, 3D dynamic network view.

Decompositions

A categorisation with keywords commonly offers little information on the importance of a concept as specified by a document keyword, or on the portion of a document this keyword applies to. Furthermore, users may opt to simply ignore keywords which apply to only part of a document. In this way, document keywords offer a quantitative rather than a qualitative valuation of the document. Instead, by allowing the user to select portions of a document to assign keywords to, many more keywords that better fit parts of documents can be specified and associated with the appropriate document portions. This makes the documents inherently related by content.

This requires the ability to decompose a document into a collection of document entities, hierarchically organised corresponding the decomposition, where each component can be independently located in the information space. Such a decomposition assists in locating parts of documents more accurately, while automatically linking to the main document, thereby increasing the effectiveness of a subsequent search. Decomposing documents by content also creates a richer information structure. Replacing documents with component structures automatically increases the number of information entities. Decomposition relationships between document components extend the network of relationships.

Document decompositions can be represented in various ways. We consider a structural decomposition of a document as opposed to a semantic one, that is, document entities are defined as subsets of the overall document and using the same representation. This approach to decomposing documents provides a uniform structure that is easily adaptable. In this structure, the semantics of the decomposition are separately specified through the categorisation of the document entities. Such a structural decomposition particularly applies to texts, images, and simple line drawings, as these lack any strong inherent structure. All composed of symbols from a relatively small vocabulary, i.e., characters, pixels, and line segments, in simple one- and two-dimensional patterns, they are represented in a similar structure and can be operated on in a similar way: divided into smaller parts and the parts organised into a hierarchical structure (figure 4).

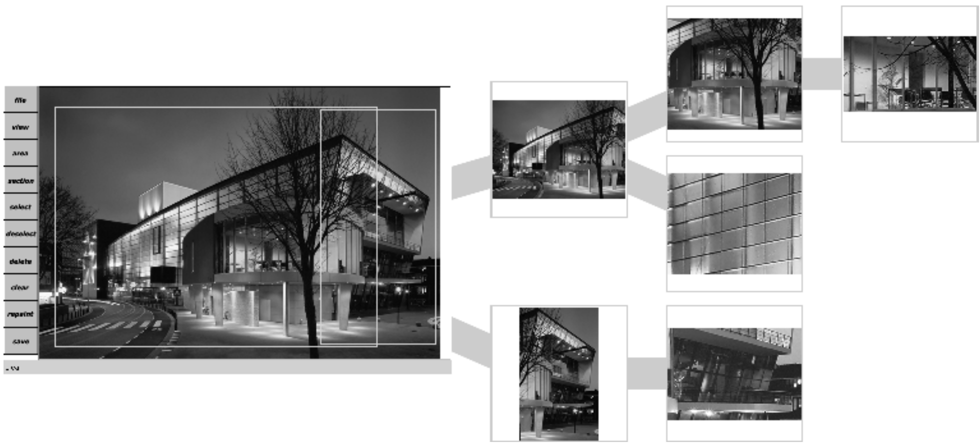

Figure 4. An exemplar image decomposition: left, snapshot from the image decomposition tool with two rectangular areas marking two image components; right, an image decomposition hierarchy.

Compositions

Once information and documents are collected electronically, many related activities can gain an efficiency that previously might not be thought of. An engineering partner disclosed that on a large construction project involving a variety of companies, authorities, and organisations, one single person was kept busy all week long copying and mailing about 50.000 pages of letters and reports to the different parties. Using the Web for distributing information could save one person a tedious job and improve the time it takes to keep everybody up to date. Reports can easily be assembled from the available information. An application was developed to assist in the generation and distribution of project reports. Using dynamic HTML, this application enables the user to specify the pieces of information to be included, then lay them out on a web page, and subsequently store the layout for the specified addressees (figure 5).

In a more general form, this supports the ability to compose a “document” from a collection of entities that are already present in the information space, maintaining all relationships to these entities. The composed entity can be located independently of its component entities in the information space. The resulting document is strongly embedded in this space by virtue of its relationships to the composing entities. This document can be considered to constitute a particular view as specified by the author and, through these links, this view may be reinterpreted by another user into a new and different view that particularly reflects on this user’s interest.

Another application in the educational context allows for the specification of an image map, by adding hotlinks to an image, that can serve as a content map or index to a collection of related documents. The base image may constitute a plan of a building, markers can then be positioned on the image and related to the appropriate documents: section markers indicate where on a plan a section is taken, and in which direction; view markers define where a picture or an elevation is located in relation to the plan (figure 6).

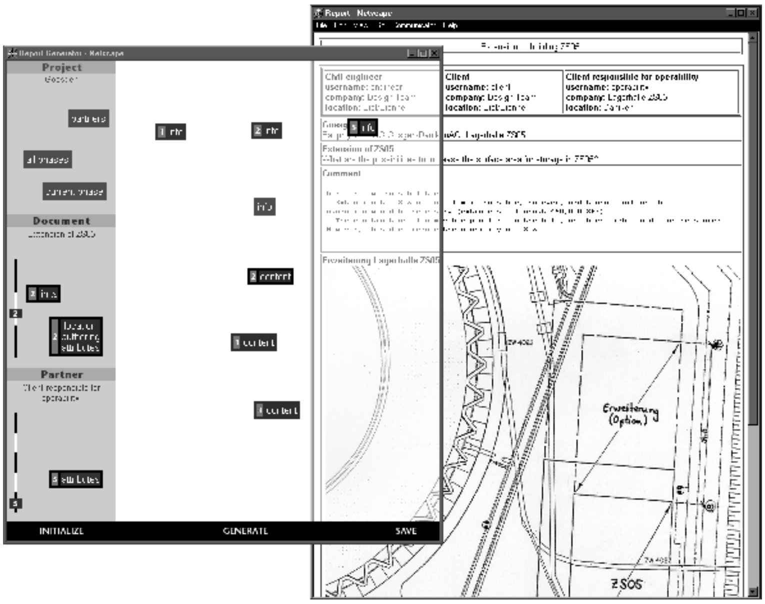

Figure 5. Report created with the report generator application: left, the layout specification; right, the resulting report.

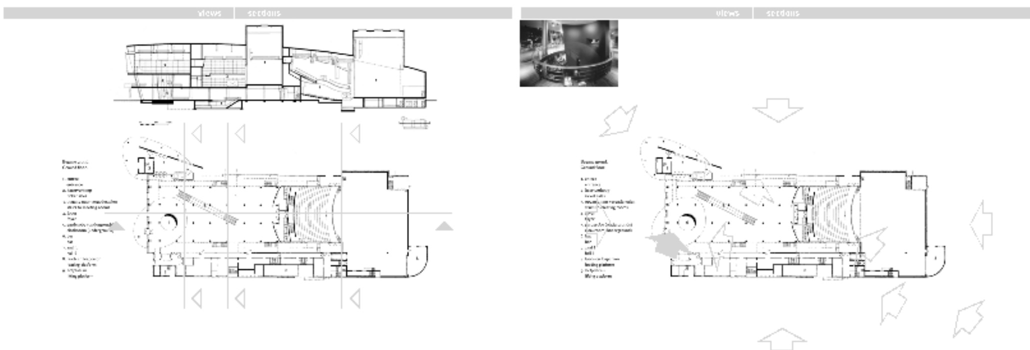

Figure 6. Generated web pages containing image maps that serve as a content map or index to a collection of related documents: left, image map with section markers; right, image map with view markers. When one moves the mouse pointer over a marker, a preview image of the related document appears. Markers can be clicked to browse to the respective document.

Information visualisation

Effective visualisations of information structures are indispensable in order to empower an understanding of the collaborative processes that led to these structures [13]. Using graphical (2D and 3D) maps of various nature, an entity can be viewed within its context defined both by its location and by its relationships to other entities within the information space. A variety of visualisations will enable different viewpoints on the same or different information, potentially presenting alternative arguments or reinforcing the same argument. Visualisations must be flexible enough to respond to the requirements and preferences of the individual partner, enable a focus on individual issues, or present arguments that may be unexpected or otherwise difficult to grasp. Together, these should enable a more effective and efficient collaboration among the participants through a visual analysis of the information structure(s) and the underlying collaborative processes serving both the retrieval and storing of an information entity.

Conclusion

Together, these abilities offer the user a vocabulary with which to express his or her intent in using the collaborative information space. They do not only offer the user additional freedom in locating a document entity into the information space, but also provides immediate feedback on the contribution this individual addition makes to the entire information space. Their use should not only offer the insights a search and retrieval may provide at the time of adding the information, but also empower the author to actively participate in the design of this information space.

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