

A Personalized Multimedia System for Optimizing Civil Engineering Processes

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ABSTRACT: Building and construction processes heavily rely on an intense and timely cooperation between many participating partners. In this paper a computer-based support system is described which gives all participants their individual and adapted view to the process. The system is based on standard technologies from the world wide web. Thus it reached quite a broad dissemination within only two years of being on-line. The functionality of Bau-CSCW in the planning phase as well as the core technological concepts are being described.

1 INTRODUCTION

Civil Engineering, as no other industry, relies on a tight cooperation between all participating partners in construction projects. In small or medium sized projects, often hundreds of partners and companies are involved. They are working together and in cooperation to create individual one-of-a-kind objects in changing environments and settings. During this construction process, each participant has a unique and individual view onto the data of the building to be constructed. The system described in this paper offers the opportunity to generate and maintain individual views on a common work process in civil engineering projects.

In the beginning of each construction process, the building owner determines the kinds of utilization the construction object will possess. Based on these selections, the building owner will look for an architect, who has the appropriate skills and will work on the details of the project. Together with the owner of the building, the architect will refine the plans for the construction object and will consider any legal, commercial, or financial restrictions. This initial work will end up with construction plans being delivered to and surveyed by the proper local, state, or government authorities. In case of a positive feedback from the authorities, these plans will be the basis for the subsequent work of other participating partners in the project. E.g. a stress analyst will

calculate the appropriate construction details for building a solid, safe and cost-efficient object.

In fall 1996, a web-based CSCW¹ system, called "Bau²-CSCW", for the construction industry was proposed in order to optimize the time-critical and communication-intense construction and planning process. In spring 1997, the system was introduced to the public and gradually made accessible over the Internet (<http://www.bau.net>). As of this writing, over 3500 building owners and more than 250 construction companies used components from the system (Handwerk 1998, Haus & Markt 1997).

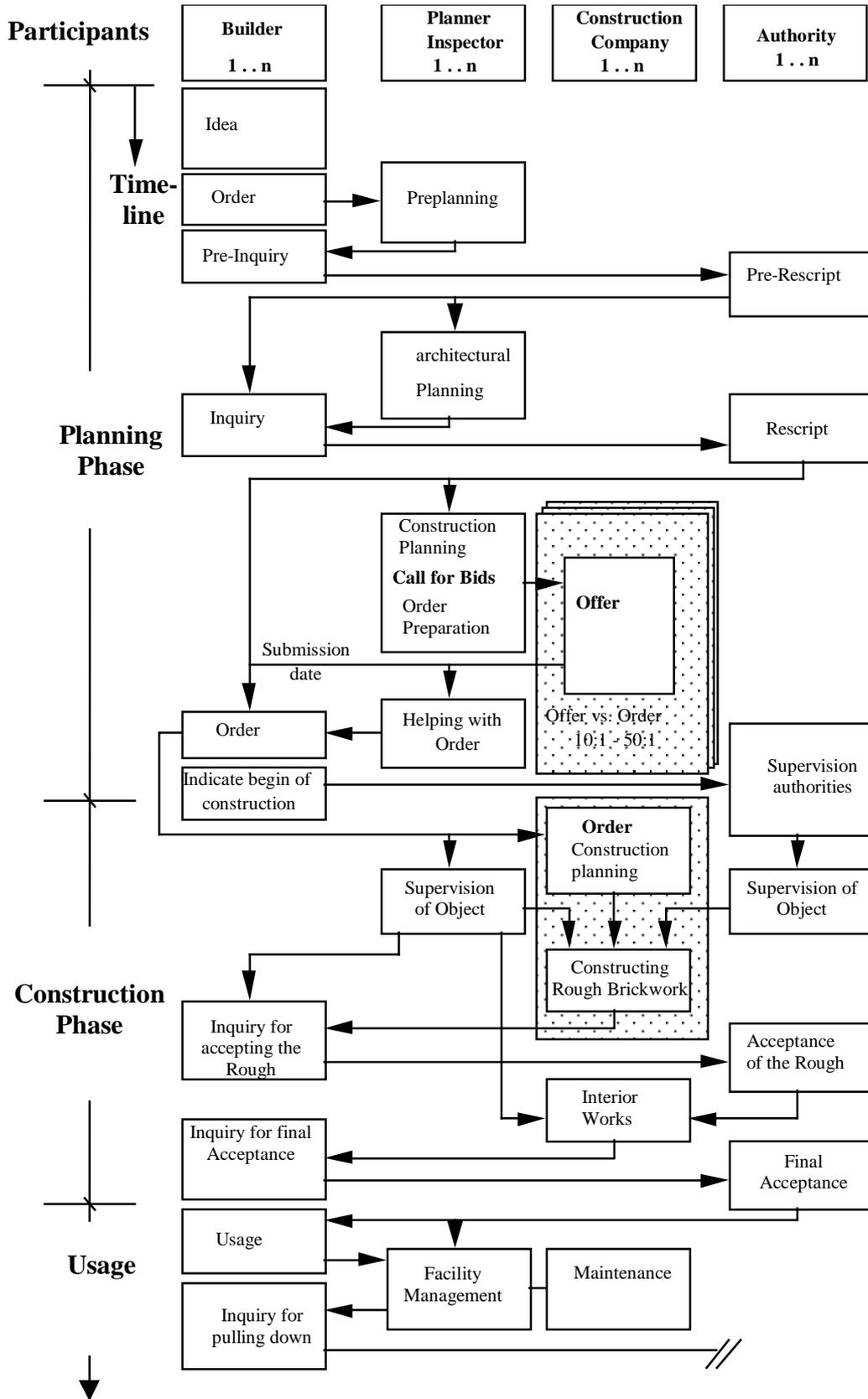
2 FUNCTIONALITY

Figure 1 illustrates a generic construction workflow and how the partners in a typical construction process interact. This workflow follows the german regulations and is not transferable to other countries without reengineering it. During the design and construction process, the plans and data for the construction object are generated and further refined. It is important to mention, that during this process, partners are called in and drop out according to their function and role in the overall project. E.g. the stress analyst is only needed and consulted in the beginning of the whole construction project. As soon as the design of the object is finished, he will do his

¹ CSCW = Computer supported cooperative work

² Bau (german) = building, construction

Figure 1: A generic construction workflow

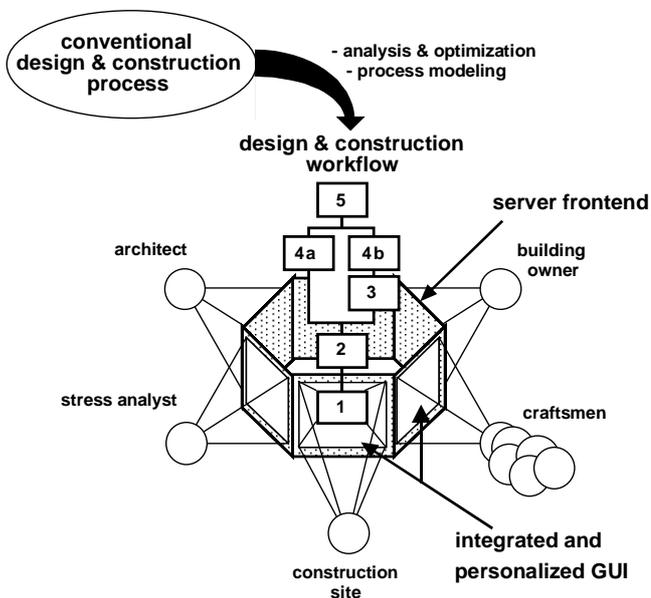


calculations and will afterwards not actively participate any more in the process. The system has to take account for this dynamically changing group of partners working together on the completion of the project.

The construction project workflow presented in figure 1 is the basis for controlling the construction process in the “Bau-CSCW” system. For each participant the system is offering a unique and individualized view onto the construction workflow

within the construction process. With this method, it is possible to offer each participant that kind of information needed to accomplish the designated work. The single partner in the construction project is not overloaded by information and data not being relevant for his tasks, but will get exactly that information delivered to solve the assigned part in the construction process. Even more, this information can be presented personalized and in a way and form most familiar to the participant. This increases the overall performance and reduces costs by cutting the time needed for each task. Figure 2 illustrates these individualized views onto the construction workflow. E.g. the participating craftsmen do not see all data of the project, but only those plans, that are relevant for their tasks.

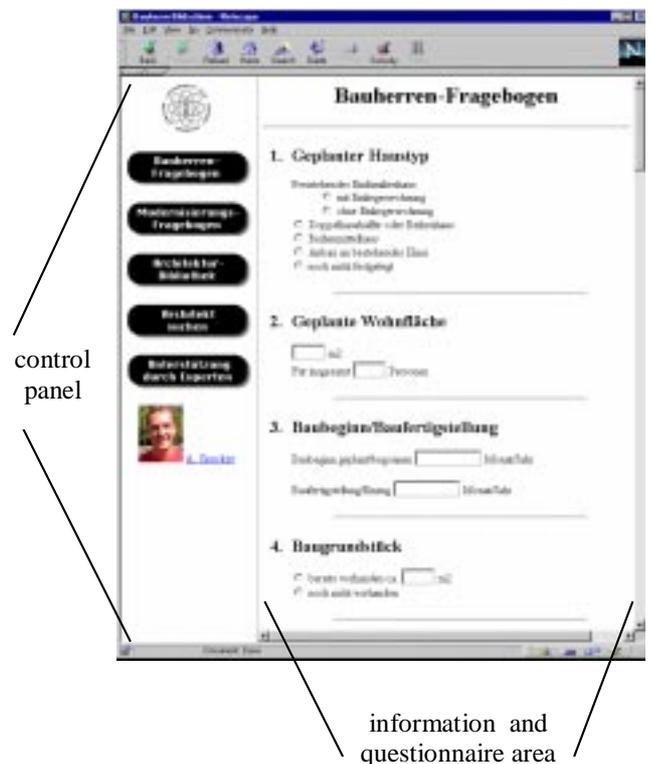
Figure 2: Individual views onto the construction process



3 PRACTICAL DEPLOYMENT

The “Bau-CSCW” system offers at the beginning of the construction process a guided view for the building owner to make his ideas of the targeted object more concrete. For this purpose, a questionnaire (figure 3) is used to ascertain a detailed requirement analysis for the construction object. Figure 3 also shows the look-and-feel of all views for all participants. On the left a control panel is offered for navigation and selection purposes. The major screen area is taken by the respective view currently being presented.

Figure 3: Building owner questionnaire



For building owners who are modernizing already existing buildings a special modernization questionnaire is offered (see figure 4).

Figure 4: Modernization questionnaire



Additionally, an architectural library (see figure 5) helps the owner to clarify his ideas and explain them to experts, or in a later stage to the involved architect. In this library floor plans and pictures of already existing buildings are collected and the

building owner or other interested users can browse through this catalog to find appropriate examples. While browsing through this catalog, the building owner can activate check-boxes to document and mark interesting objects and building details.

Figure 5: View to the architectural library



During this refinement process of the construction idea, an audio/video conference with an expert can be established at any time. With a button always present in the control panel, this functionality is easily accessible and the information and data being collected so far can be viewed by the expert. The building owner and the expert have the same information at hand and can discuss the ideas for the new construction object. Application sharing and browser coupling are technical means used here.

As soon as the refinement process of the project reaches a certain level of detail, the system offers a button to the building owner to find an architect. The proposed architects are registered with the system and have the ability and skills to work on the subsequent phases of the project towards the completion of the construction object. By invoking this function, the so far generated data is transformed into a format suitable for architects. Registered architects are automatically informed by the system about the upcoming project. The architects can now browse through the data generated by the system and decide whether to participate and make an offer for the project or not.

By the end of the planning phase, the architect selected for the project generates a call for bids to get offers from various construction companies and craftsmen (see figure 6).

Figure 6: View of the architect



In this call for bids, all parts of the construction project are described and distributed to the registered construction companies or craftsmen. The distribution of the call for bids is automated by the system in two ways: first the bids are sent automatically to registered companies and second, construction companies or craftsmen that are not registered with the system can access the server of the system and browse through the bids. Since the calls for bids are generated and stored electronically, it is possible to dynamically update the information the calls contain. This is the case when the building owner or architect decides to make changes to the construction object during the refinement process of the planning phase. All update processes of the call for bids are password protected to prevent misuses of the system and can only be performed by the architect or by the building owner.

For the automated distribution and publication of the call for bids, all necessary documents are published on a WWW-server. Registered users, like craftsmen or construction companies, are informed by email of new content and new call for bids on the server. The practical experiences showed, that the easily accessible web-server is a well accepted and efficient distribution channel for the bids. In the notification email for the users, a link to the call for bids and other related documents is included to further simplify the access. This is important to increase the acceptance of the system in the construction industry, where information technology is at the moment only infrequently deployed.

Each company accessing the server can maintain a company profile which is password protected. With this profile, call for bids are automatically filtered to match the company's field of experience. Also a personalized view for accessing the content

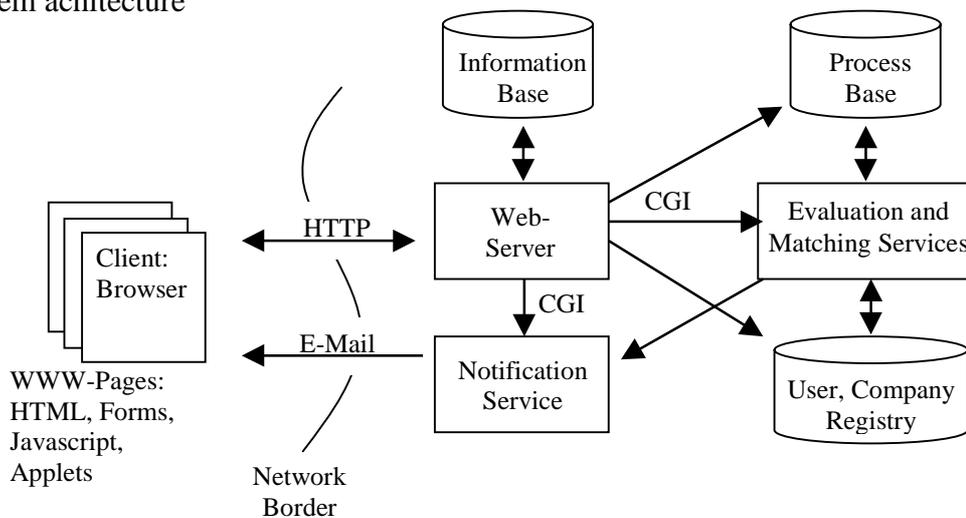
of the server can be engaged. The options in the profile are for example to filter the call for bids by using the postal code of the construction site or special fields of interest. The profile is easily maintainable within the system by using a standard web-browser. A similar interface as those already shown provides the view to company profiles.

4 SYSTEM ARCHITECTURE

The "Bau-CSCW" system uses the World Wide Web, WWW (Berners-Lee et al. 1994), as its

When clients create a new construction workflow using the information base, this new process gets stored in the process base. Here each building process is maintained through all of its workflow phases. Since the process can be represented as one or a sequence of HTML documents, clients can observe the current state of processes. Processes are uniquely identified through URLs (URL = universal resource locator, (Berners-Lee et al. 1994)). At some stages in the process evaluation and matching tasks have to be performed. For instance, a call for bids has to be evaluated and matched against possible offering companies, or a suitable architect has to be

Figure 7: System architecture



technological distribution infrastructure. The deployment of web technology provides platform independence and a broad public accessibility of the system. The "Bau-CSCW" system follows a multi-tier client/server architecture as depicted in figure 7. The system can be extended at any time by integrating additional service modules and updating the web server contents accordingly. The multi-tier client/server architecture is very flexible by deploying standard communication and activation procedures like HTTP, CGI-Scripting, or email notification.

The clients deploy standard web browser software which accesses a central WWW server over the hypertext transfer protocol, HTTP (Berners-Lee et al. 1994). At the server site this WWW server retrieves desired data from its information base. This information base serves as a storage area for static information such as the architectural library or the form and questionnaire templates. All this information is represented by HTML documents (HTML = hypertext markup language, (Morris 1995)). Currently the information base utilizes the standard file system of the server.

found to conduct the building and construction of a certain project.

For such purposes specific services are provided which are triggered by the WWW server through respective CGI interfaces (CGI = common gateway interface, (Herrmann 1996)). For the matching the services can consult the process base as well as the registry where user and company profiles are being held. These profiles are again represented by HTML documents and can thus be entered and maintained using the standard WWW browser as a frontend. After a matching task has commenced the services inform the notification service in order to trigger the sending of an appropriate email to the user or company.

Email content is automatically generated from input parameters the services provide combined with email templates known by the notification service.

A special kind of notification is the invitation to an audio-video conference. Here the notification email contains means to invoke and join audio-video conferences using WWW-external conferencing systems, such as Microsoft's Netmeeting, as helper applications.

4.1 Application Example of Services and Notification

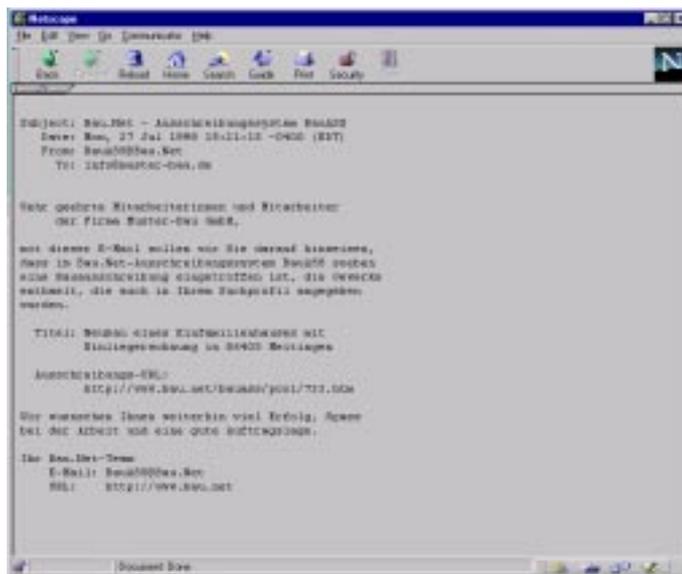
As an example, the creation and distribution of a call for bids is described to clarify the interaction of the single components in the system. As soon as the architect finishes the preparation of the call for bids in his web browser interface, this call for bids is transmitted to the web server for further processing (see figure 8).

Figure 8: Preparing a call for bids



The web server evaluates the transmitted form and check-box data and hands this information over to a CGI script. This script, which is part of the Call for Bids Service, checks the data for plausibility and stores it in a database system for future retrievals. At the same time, when the client data is handed over to the CGI script, the web server will invoke the Notification Service. The Notification Service checks the database for the availability of the new call for bids.

Figure 9: Email distributed through the Notification Service



Is the call for bids available and positively checked for plausibility, the Notification Service will retrieve a list of companies and craftsmen that are interested in this special kind of call for bids. These companies and craftsmen are informed by the Notification Service via email about the availability of a new call for bids (see figure 9). This notification email contains an URL pointing to the web server of the system where the call for bids can be accessed. This automated procedure of distributing call for bids to interested parties is a major advantage of the system presented in this paper.

5 CONCLUSION

The dissemination of the "Bau-CSCW" system to roughly 4000 users proves the validity and success of such computer support in building processes in civil engineering. The system is currently freely available to builders and to construction companies. It is financed by advertisement and sponsoring.

The broad usage is due to the extremely low learning curve of using the system. This is enforced by the individual views to the process which takes the different knowledge and interest about process phases into account.

Currently the system is only available for the german market, since construction workflows are national. Anyhow, major parts of the system could be easily reused in an international setup.

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