A WWW BASED SYSTEM FOR THE SUPPORT OF CONSTRUCTION PROCESSES

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ABSTRACT

Building and construction processes rely heavily 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 own customized view of the process. The system is based on standard world wide web technologies. In this way it has achieved wide exposure within only two years of being on-line. The functionality of Bau-CSCW especially in the planning phase of a generic design and construction workflow as well as the core technological concepts is described.

INTRODUCTION

For most industrial countries civil engineering is of major importance for their economies. Compared with other production industries like mechanical or electronic engineering, civil engineering can be characterised as producing mainly one-of-a-kind objects. For the production of these one-off objects a large number of partners with different key competencies and locations are involved over a long period. Intensive cooperation among all participants is a major prerequisite towards cost-efficient working and on-time project completion. During this construction process, each participant has a unique and individual view of the data of the building under construction.

For instance, at the beginning of each construction process, the owner determines the various facilities and uses the construction will require. Based on these choices, the owner will look for an architect, who has the appropriate skills and will work on the planning details. Together with the owner, the architect will refine the plans for the construction and will also consider any legal, commercial, or financial restrictions. This initial work will end with construction plans being delivered to and surveyed by the proper local, state, or government authorities. In the event of 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. Obviously, owner, architect and stress analyst have different views of the process and will focus on different data.

The above process outlines requirements which can be supported by a suitable IT infrastructure. The need for and use of computer support in construction processes has been the focus of several efforts such as e.g. (Amor 1997, Betts 1992, Betts 1997, Eren and Kuhlmann 1996, and Scherer et al. 1997).

The system described in this paper offers the opportunity to generate and maintain such individual views of a common work process in civil engineering projects in order to optimize the time-critical and communication-intensive construction and planning process. Since spring 1997 the system, called "Bau-CSCW[1]", was introduced to the public and gradually made accessible over the Internet (`http://www.bau.net`). Up to the time of writing, over 4000 building owners and more than 300 construction companies used components from the system (Handwerk 1998, Haus & Markt 1997).

[1] Bau (german) = building, construction
CSCW = computer supported cooperative work

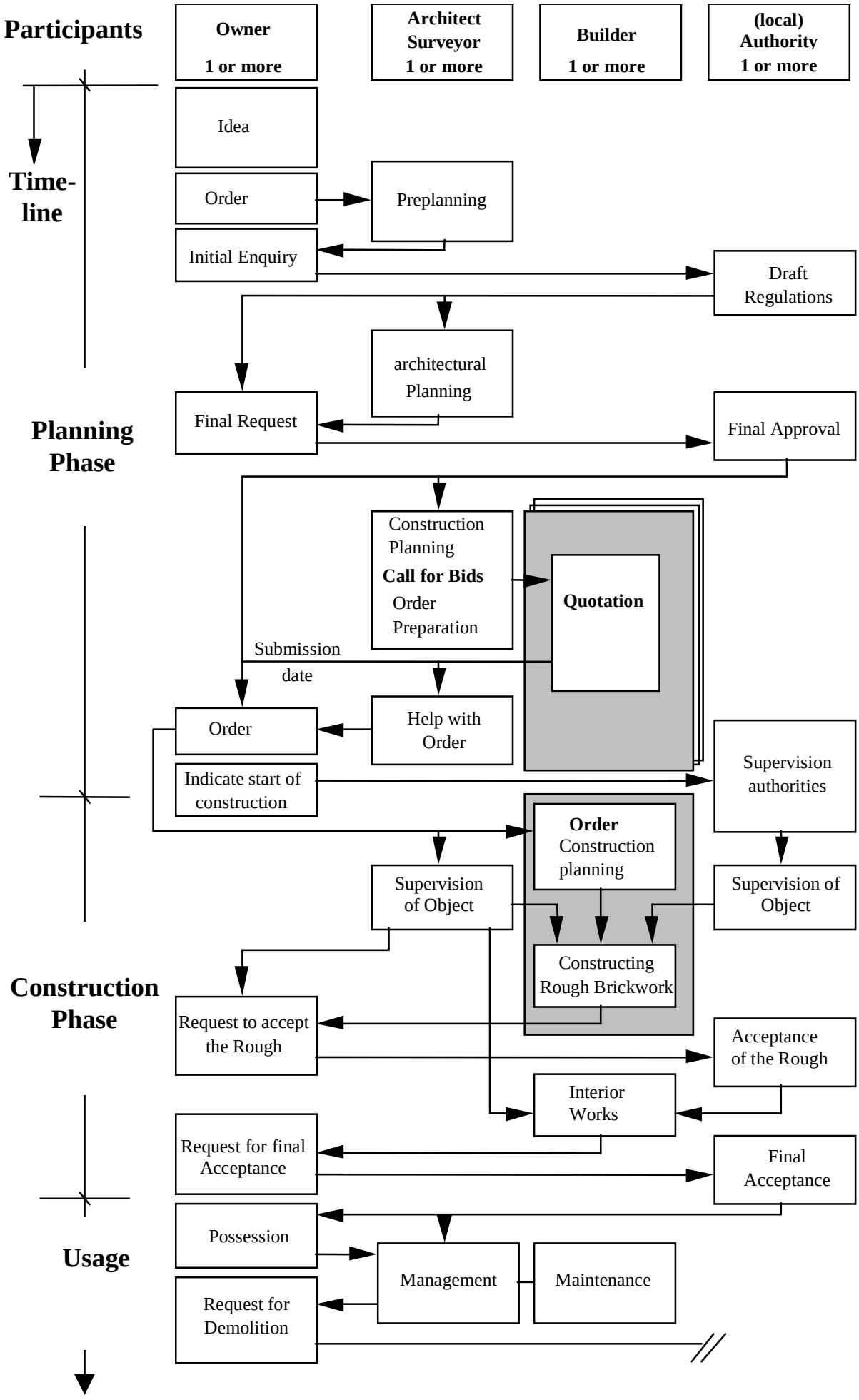

Figure 1: A generic construction workflow

CONSTRUCTION PROCESS AND WORKFLOW MANAGEMENT

The "Bau-CSCW" system utilizes a generic construction project workflow (Jablonski and Bussler 1996) as the basis for controlling the construction process (figure 1). The workflow comprises three major phases. During the planning phase all roles (owner, architect and surveyor, builder and authority) are involved. A major emphasis is put on selecting partners for the undertaking. An architect has to be found, bids and offers have to be evaluated, regulations have to be followed in order to finalise the planning and with it the team building.

The second phase deals with the construction itself. The main work-load here is on the builder, but still all roles are involved. In the third phase the building is used and maintained. For this purpose facility management tools should be employed. We currently do not intend to cover this phase in our system.

During the entire process for each participant a unique and individualised view of the design and construction workflow is presented. With this method, it is possible to offer each participant the kind of information needed to accomplish his designated work. The single partner in the construction project is not overloaded by irrelevant information and data for his tasks, but he will be provided with the exact information required to meet his the assigned role in the construction process. Furthermore, this information can be personalised and then presented in a way 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 individualised views of the design and construction workflow, e.g. the participating craftsmen do not see all project data, but only those plans that are relevant for their current tasks.

The design and construction workflow complies with German regulations and is not transferable to other countries without re-engineering 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. For example the stress analyst is only needed and consulted at the beginning of the whole construction project. As soon as the design of the object is finished, he will do prepare his calculations and afterwards will not actively participate any more in the process. The system has to take account of this changing group-dynamics among partners collaborating on the completion of the project.

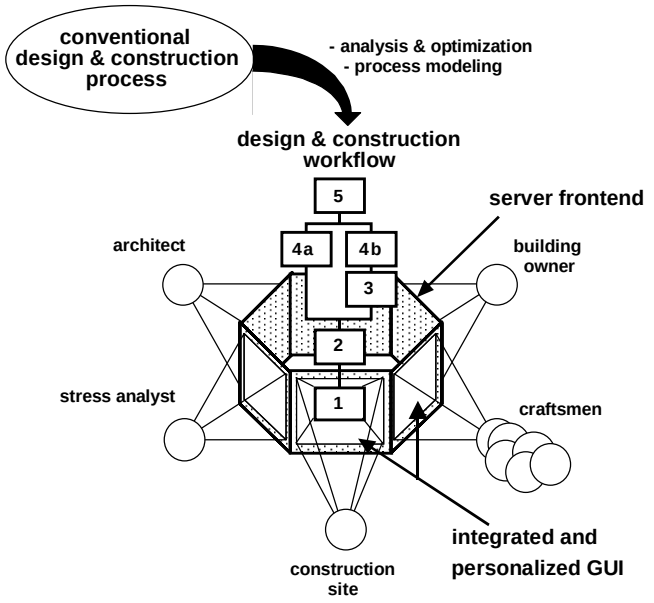

Figure 2: Individual views of the construction process

USAGE SCENARIOS

The "Bau-CSCW" system offers at the beginning of the design and construction process guided view for the owner to make his ideas for the target 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 hand side a personalised control panel is offered for navigation and selection purposes. The major screen area is taken up by the respective views currently being presented.

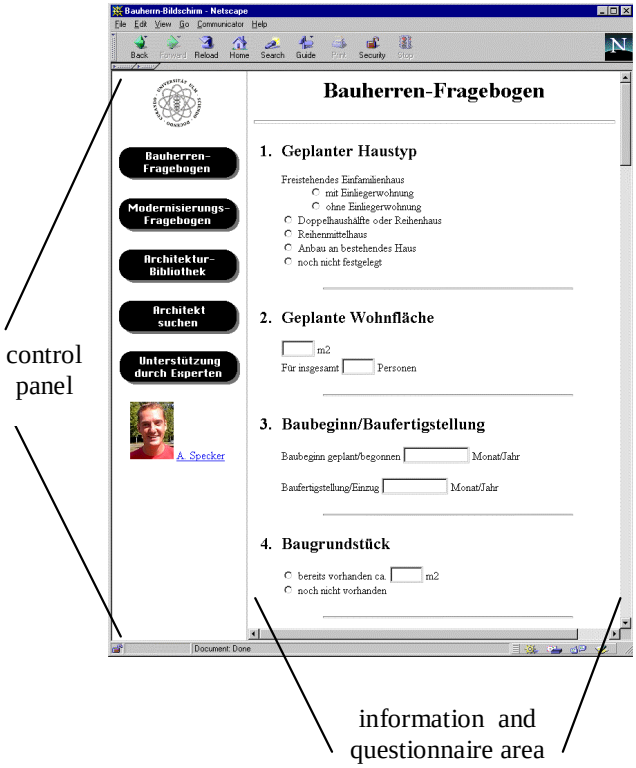

Figure 3: Building owner questionnaire

For building owners who are modernizing already existing buildings a special modernization questionnaire is offered (figure 4), since different process steps are required in this case.

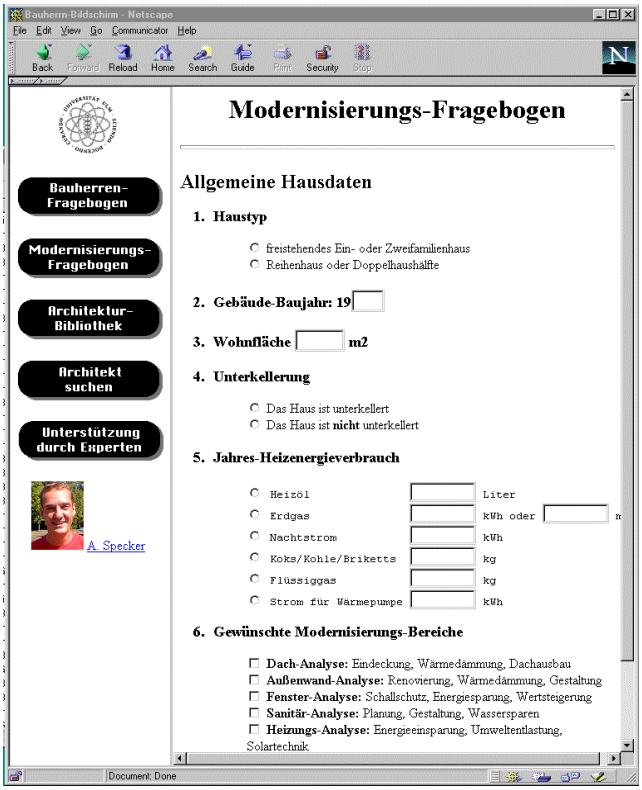

Figure 4: Modernization questionnaire

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

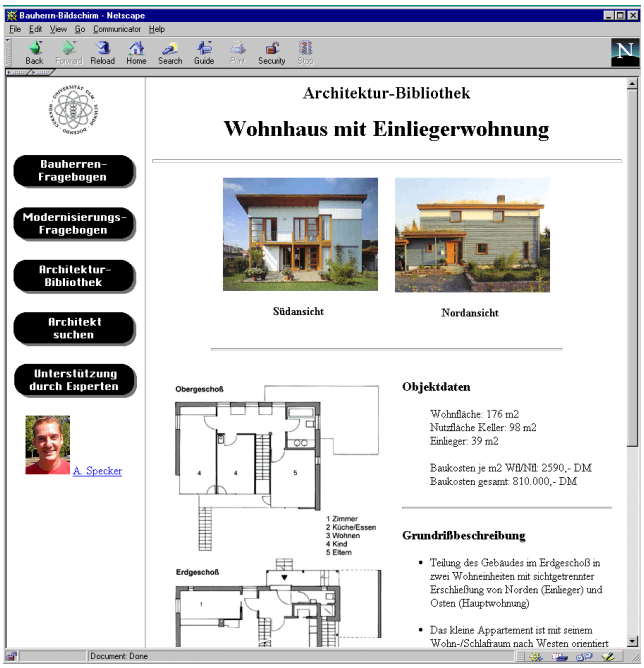

Figure 5: View of the architectural library

During this refinement process of the construction idea, an audio/video conference with an expert can be established at any time. With an ever-present button on the control panel this function is easily accessible and the information and data being collected so far can be viewed by the expert. The owner and expert have the same information to hand and can discuss the ideas for the new construction object. Application sharing and browser-coupling are the technical means being 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 data generated so far 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 an invitation for bids to get offers from various construction companies and craftsmen (see figure 6).

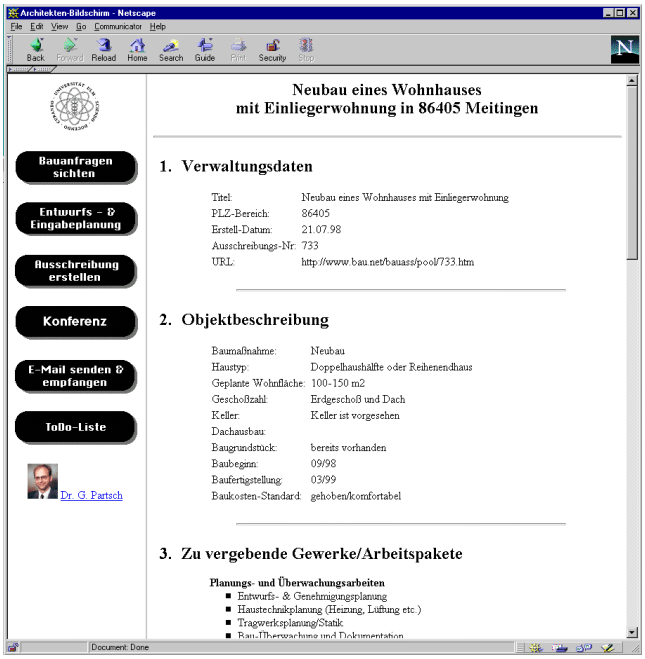

Figure 6: View of the architect

In this invitation for bids, all parts of the construction project are described and distributed to the registered construction companies or craftsmen. The architect may use commercial CAD tools to specify the construction plans. Figure 7 shows the integration of the tool ALLPLAN FT from Nemetschek AG, Munich, into the personalised desktop for architects.

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 update the information the calls contain dynamically. This is the case when the building owner or the architect decide to make changes to the construction object during the refinement process of the planning phase. All updating processes of the call for bids are password-protected to prevent misuse of the system and can only be performed by the architect or by the owner.

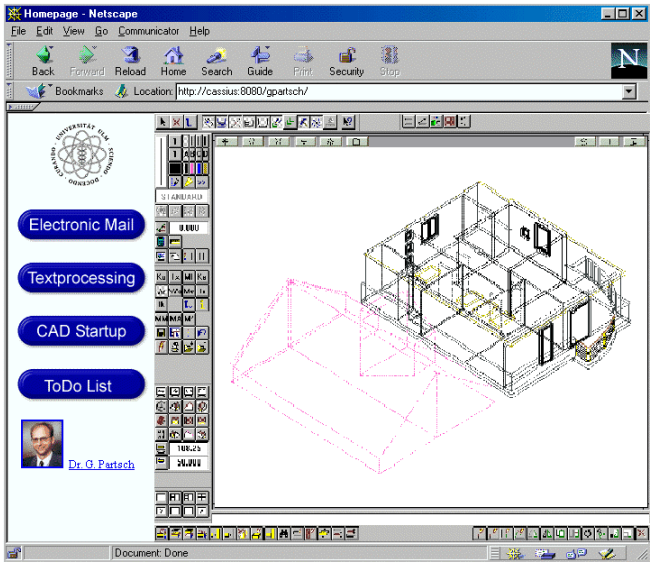

Figure 7: Integration of a CAD tool

For the automated distribution and publication of the call for bids, all necessary documents are published on the systems web server. Registered users, like craftsmen or construction companies, are informed by e-mail of new content and new calls for bids on the server. Practical experience shows that the easily accessible web server combined with e-mail notification is a well accepted and efficient distribution channel for the bids. In the notification e-mail for the users, a link to the call for bids and other related documents is included to simplify access further. This is important for increasing the acceptance of the system in the construction industry, where information technology is still only infrequently deployed.

Each company accessing the server can maintain a company profile which is password-protected. With this profile, calls for bids are automatically filtered to match the company´s field of experience. Also a personalised view for accessing the content of the server can be engaged. The options in the profile exist, for example, to filter the calls for bids 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 to those already shown provides the visualisation of company profiles.

SYSTEM ARCHITECTURE

The “Bau-CSCW” system uses the World Wide Web, WWW (Berners-Lee et al. 1994), as its technological distribution infrastructure. The deployment of web technology provides platform independence and a broad public accessibility to the system. The "Bau-CSCW" system follows a multi-tier client/server architecture as depicted in figure 8. The system can be extended at any time by integrating additional service modules and updating the web server content accordingly. The multi-tier client/server architecture (Orfali et al. 1996) is very flexible through use of standard communication and activation procedures like HTTP, CGI-Scripting, or e-mail notification.

The clients use 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, (Wilde 1998)). Currently the information base utilizes the standard file system of the server.

When clients create a new design and 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 steps can be represented as a single document or a sequence of HTML documents, clients can observe the current state of processes through their browser. 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 potential supplier companies, or a suitable architect has to be found to supervise 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, (Gundavaram 1996)). For matching purposes the relevant services may 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 e-mail to the user or company.

E-mail content is automatically generated from input parameters which the services provide,

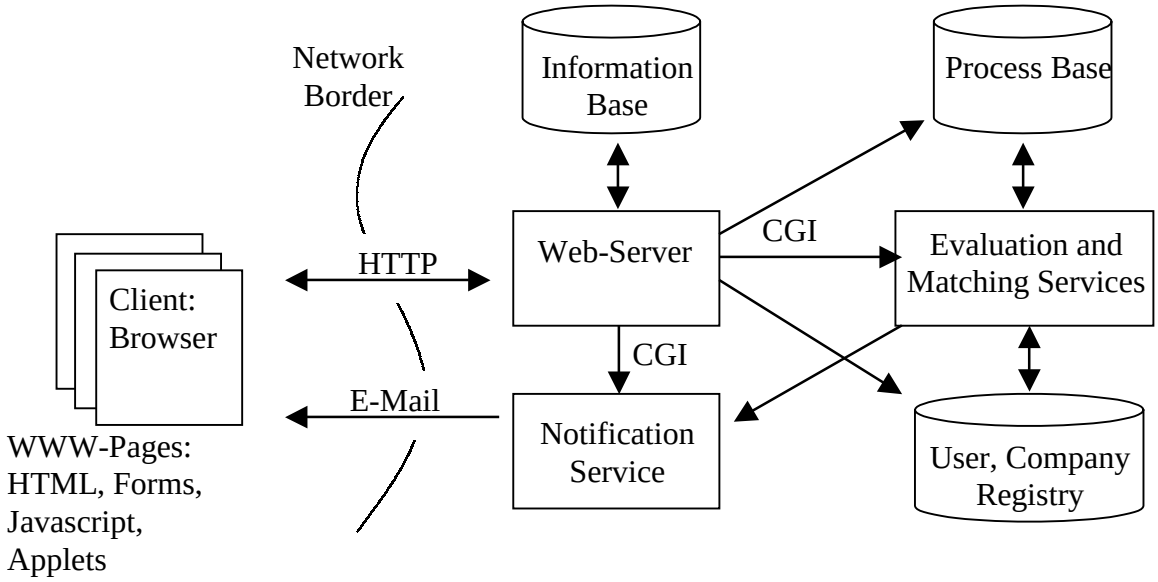

Figure 8: System architecture

combined with e-mail templates known by the notification service.

A special kind of notification is the invitation to an audio-video conference. Here the notification e-mail contains means to invoke and join audio-video conferences using web-external conferencing systems, such as Microsoft´s Netmeeting, as helper applications. The integration of other external software such as the CAD tool is also done through the helper application mechanism.

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 finalises the call for bids in his web browser interface, this call for bids is transmitted to the web server for further processing (see figure 9).

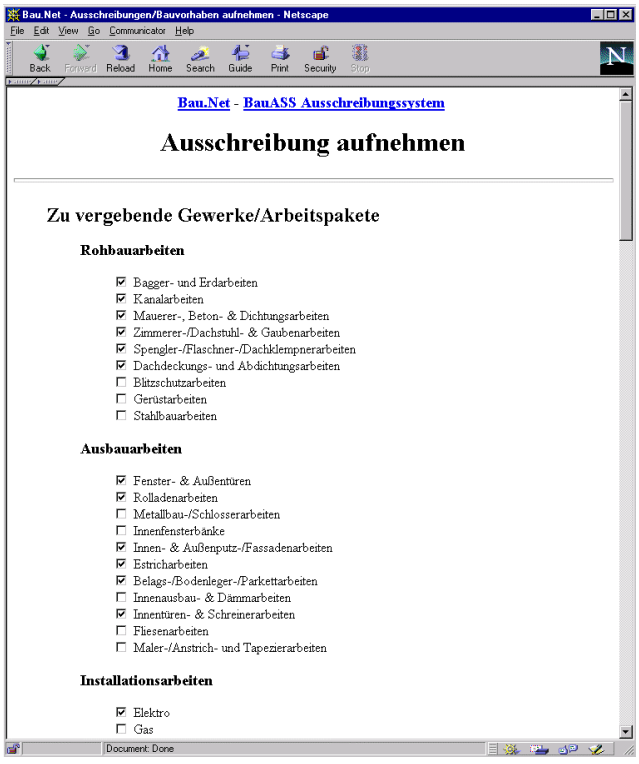

Figure 9: Preparing a call for bids

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 presence of new calls for bids.

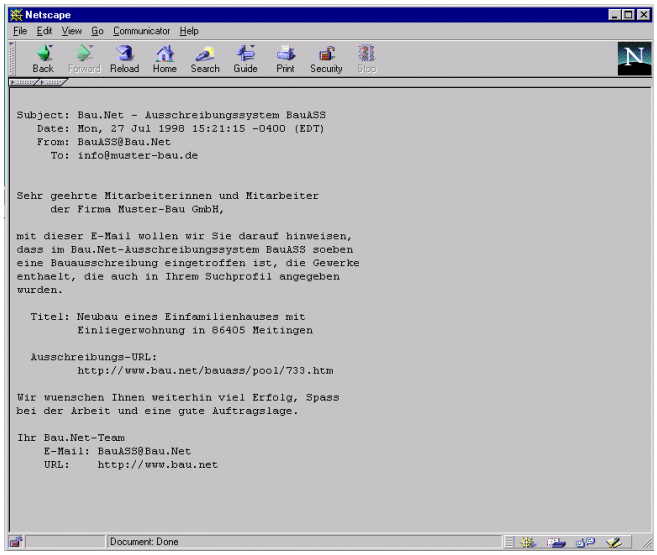

Figure 10: E-mail distributed through the Notification Service

Should such calls for bids be present and have been 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 e-mail about the availability of a new call for bids (see figure 10). This notification e-mail 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 key success factor of our system.

CONCLUSION

The architecture of the system developed in this research project concentrates on a user-friendly interface, providing simple maintenance and reducing client-side based complexity. These goals are achieved by utilizing standard software components in order to build an efficient communication and cooperation infrastructure. Particularly in the context of, but not limited to civil engineering, these support mechanisms are of major importance, improving and optimizing the

whole design and construction process significantly. The implemented prototype shows the personalised integration of standard software components and multimedia web technologies in order to suit the users´ needs and skills. This integration can be demonstrated to have a practical deployment, with the users largely benefiting from such a system.

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 advertising and sponsorship.

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

Currently the system is only available for the German market, since design and construction workflows are domestic. However, major parts of the system could be easily reused in an international setup.

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BIOGRAPHIES

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