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A Web-based Information System for Project Monitoring

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Abstract
Project monitoring is an important element of efficient construction management. However, monitoring is generally hindered by the requirement for continuous and detailed information collection and dissemination among the construction sites, often spatially dispersed, and the company headquarters. This paper presents a web-based information management system that aims to overcome current deficiencies in information sharing throughout the monitoring process of construction projects. The system consists mainly of a relational database and a dynamic data-driven web site. The database contains several types of information necessary for project monitoring concerning the construction process (e.g., activity progress, resource usage, material arrival) as well as company characteristics (e.g., manpower, equipment, construction sites). Project participants access the database through the internet and can perform certain transactions such as inserting, searching, viewing, printing, updating, or deleting information by simply using a web browser. A pilot implementation has shown that the system can improve information management as it provides concise information, quick/remote access, prompt updating capabilities, and information reliability. As a result, time and cost savings, as well as higher construction quality can be expected.

Keywords
Information Management, Construction Management, Project Monitoring, Internet, Web Application

1. Introduction

The construction of civil engineering projects often experiences completion delays, budget overruns, and does not always meet the expected quality performance. These outcomes indicate a limited efficiency of the current construction management practices. Part of the inefficiency can be attributed to the lack of effective communication among task groups (Thamhain and Wileman, 1986).

Project monitoring constitutes a major component of the construction management process. Although effective monitoring is crucial for the successful completion of a project, it is not being efficiently carried out in construction as yet. The dispersed locations of the construction sites, the large amount and diversity

of information, and the wide variation of participant specialties and computer acquaintance impede effective information collection and circulation which is necessary for project monitoring. In order to surmount current deficiencies, a system that combines database and internet technologies is proposed in this paper. Apart from facilitating the project monitoring process, the objectives of the research include as well the general experimentation on data-centric web-based information management systems for the construction industry.

A number of research efforts can be found in the literature that deal with the development of web-based information management systems for the construction industry. Conceptual frameworks of systems that combine database and web technologies have been discussed in Garcia et al. (1998), and Abudayyeh (1998). Deng et al. (2001) proposed the development of an internet-based system that comprises six major functions including data exchange, emailing information exchange, internet chat, live video-cam, search engine, and auxiliary services. Regarding web-based applications in construction management, Faraj et al. (2000) proposed an IFC-based collaborative computer environment that enables the communication of distributed applications (e.g., design, estimating, planning, etc). Dawood et al. (2002) designed an internet-based information management system for commercial retail buildings, focusing mainly on drawing management. Mokhtar (2002) developed an intranet-based information model for facing the problem of incompatibility errors in drawings. A number of papers have also discussed several aspects of the conceptual framework of the internet-based information management systems while others reviewed certain case studies. Such discussions and reviews can be found in Opfer (1997), Weippert et al. (2002), Andresen et al. (2003), Lee et al. (2003), and Magub and Kajewski (2003).

With the boom of the internet, a number of professional information technology companies developed commercial web-based systems for the Architectural, Engineering, and Construction (AEC) industry. These systems are either leased as services by the so-called Application Service Providers (ASP) or sold as web-enabled software that is maintained then by the construction company itself. Such systems include Buzzsaw by AutoDesk, ProjectWise by Bentley, BuildingCenter by Briscnet, Citadon, eRoom by Documentum, e-Builder Enterprise by e-Builder, ProjectTalk by Meridian Project Systems, PrimeContract by Primavera, etc.

Another area of interest regarding information management for the AEC industry is the effort for data standardisation. Prominent efforts of such kind are the STEP (Standard for the Exchange of Product model data) standard by the International Organization for Standards (ISO) and the Industry Foundation Classes (IFC) by the International Alliance for Interoperability (IAI). The ISO-STEP 10303 is a standard for the human and computer interpretable representation and exchange of product data. The IFC standards are being developed for exchanging data between computer systems but exclusively within the AEC industry. Although the IFC standards seem promising, their applicability to date is rather limited and fruits can only be expected in the long run.
Although a number of off-the-self web-based solutions are available for the AEC industry, they cannot meet the excessive information management needs of the industry. The main limitation of the commercial web-based systems is that they are generally document-based. These systems mainly manage documents themselves rather than the information contained in them. As a result, information consistency cannot be guaranteed, nor can the absence of redundancy. Consequently, data-centric approaches may prove more appropriate for improving the efficiency of information management compared to document-based approaches. The conceptual framework of systems involving web databases has already been set (Garcia et al., 1998, Abudayyeh, 1998), however, it appears that hardly any research effort has identified the importance of providing a data-centric system. Few of the existing web-based systems involve the design of a database but, in most cases, with a rather limited information set (e.g., Faraj, 2000). Based on the above, research should further advance towards the development of a system that effectively addresses the information needs and may be practically implemented.

2. The Proposed System

The proposed system is a web-based information management system that aims to facilitate the monitoring of the construction process. Unlike common document-based systems, the present work focuses on demonstrating the potential of data-centric web databases in enhancing the communication process during project execution when prompt and effective information sharing is mostly needed for the successful project completion. Figure 1 shows information exchange among project participants with current practice and with the proposed system (the lines indicate information transfer). With current practice, information is generally transferred directly between participant pairs, using common and sometimes time consuming or expensive means, such as telephones, faxes, mobiles, mail, and in-situ visits or meetings. This can result in ineffective communication, completion delays, budget overruns, and lower construction quality. As a remedy, the proposed system attempts to organise project information in a central database accessible to authorised participants through the web. The project participants interact mainly with the system and, as a result, the information communication process becomes less complicated and easier to manage and control.

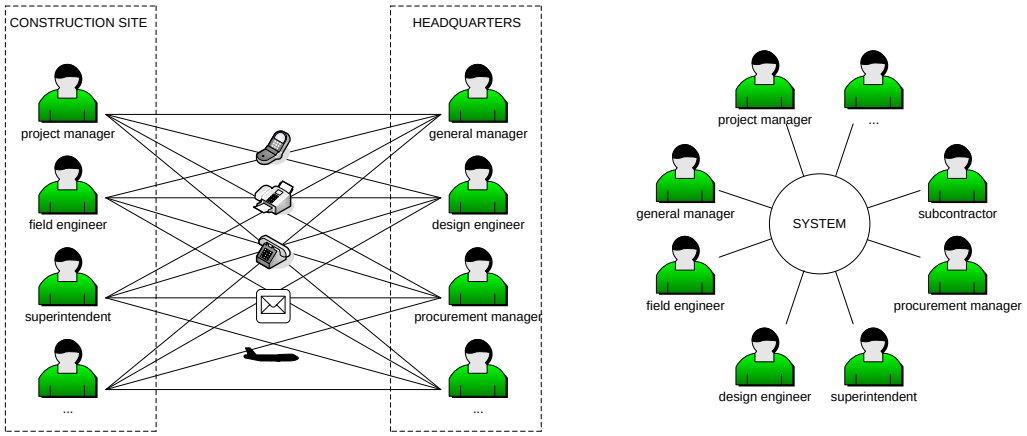

Figure 1: Information Management with Current Practice and the Proposed System

2.1 System Development

The development of the proposed system involved two types of analyses, project information analysis, which determines the type of information that will be stored in the database and project organisational analysis, which identifies the end users of the system along with their particular information needs and responsibilities. The large amount and wide dissimilarity of the information circulated in the construction process make arduous the task of information analysis. The work presented in this paper has identified information that is considered as the most important for construction monitoring (activity progress, resource usage, materials arrival, photos, videos, etc). Regarding the project organisational analysis, the company personnel and a number of external participants involved in the construction process are identified. Company personnel include the project manager, superintendents, engineers, equipment operators, craftsmen, labourers, design engineers, accountants, etc. Outside participants can be the project owner, subcontractors, suppliers, supervising authorities, consultants, financial institutions, etc.

2.2 System Design

The proposed system consists of a repository database, a web server, a web application, and end user terminals. End users access the database information through the internet using a web browser. The electronic data exchange is allowed among the project participants through a set of appropriately designed web pages. Various authorisation levels, which are controlled with usernames and passwords, determine the permitted access of an end user to particular pieces of information as well as the type of operation that

the user is allowed to perform on this information. In general, users are allowed to insert, search, view, print, update, or delete data. The database design involved loops of two main phases, entity modelling and normalisation. Entity modelling is used for determining which tables (entity types), fields (attributes), and relationships will be needed in the database management system (DBMS). The normalisation is a set of rules used to check for any anomalies in the database design. The database design resulted in 33 tables with a total of 164 fields. The most important elements of the entity model are shown in Figure 2. The boxes indicate tables, the lines relationships, and the symbols on the lines the type of relationship between tables.

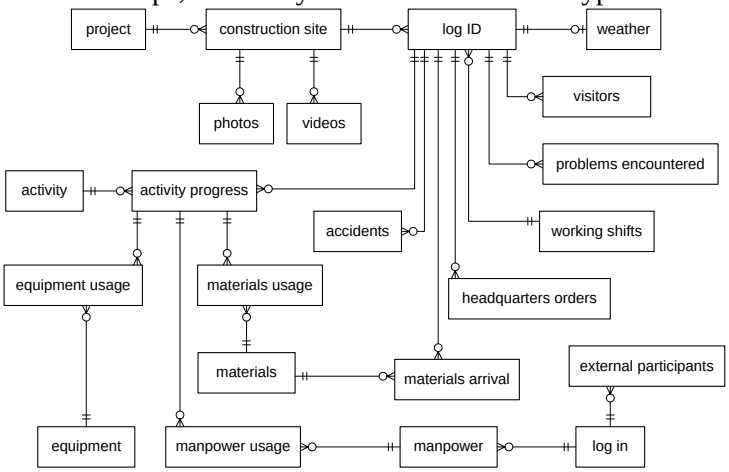

Figure 2: The major Entity Types and their Relationships

The web application consists of a set of data-driven dynamic web pages that allow the end users to interact with the database. A dynamic web page is a web page stored on a web server with partly or entirely variable content. The web application was designed following the database structure and it contains, besides the *log-in* and the *home pages*, a set of web pages for each database table: the *insert page*, the *search page*, the *results page*, the *detail page*, the *update page*, and the *delete page*. Besides the six main pages for each table, several other auxiliary pages have been designed, e.g., for verification of successfully performed actions, support pages, access denied pages, etc.

2.3 System Implementation and Application

A pilot application of the system has been set. The database has been implemented in MS-Access and the web application has been designed with Macromedia Dreamweaver MX. Among available server technologies, Active Server Pages (ASP) has been selected along with Visual Basic Script (VBScript) as the programming language. The Microsoft Internet Information Server (IIS) has been employed as the web server. Figure 3 shows a typical *search page* while Figure 4 a typical *results page*. As it can be seen from these figures, the menus are dynamic and their data are retrieved from the appropriate database fields according to the information stored in the corresponding tables at each time. The system operability has been tested with artificial data while actual case study applications are currently underway.

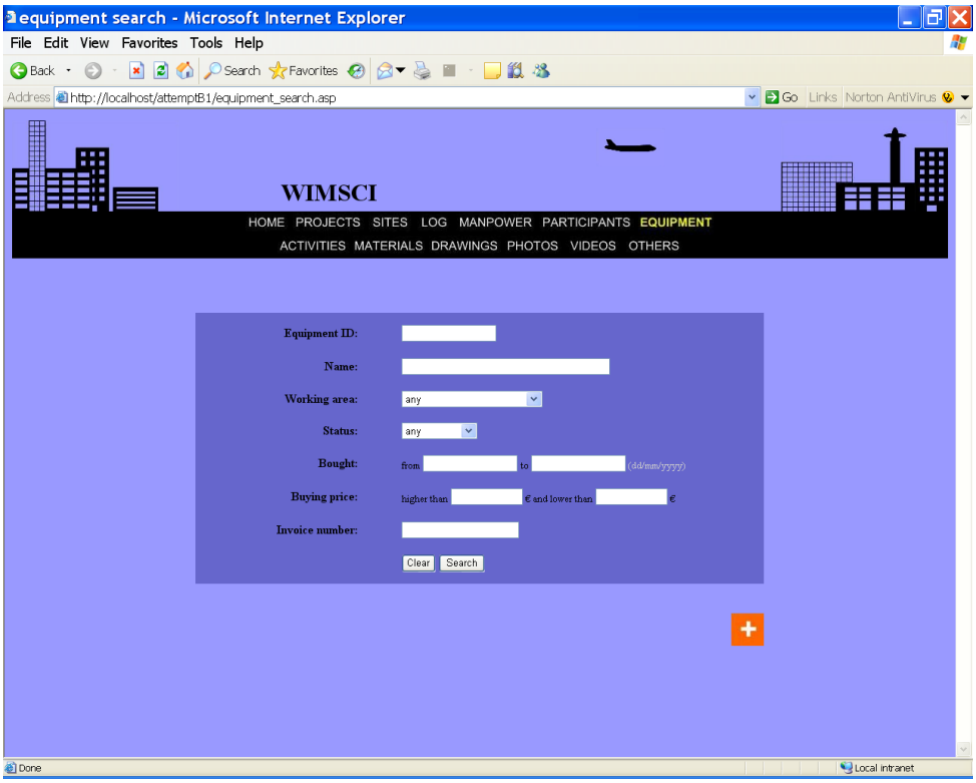

Figure 3: A typical Search Page of the Web Application

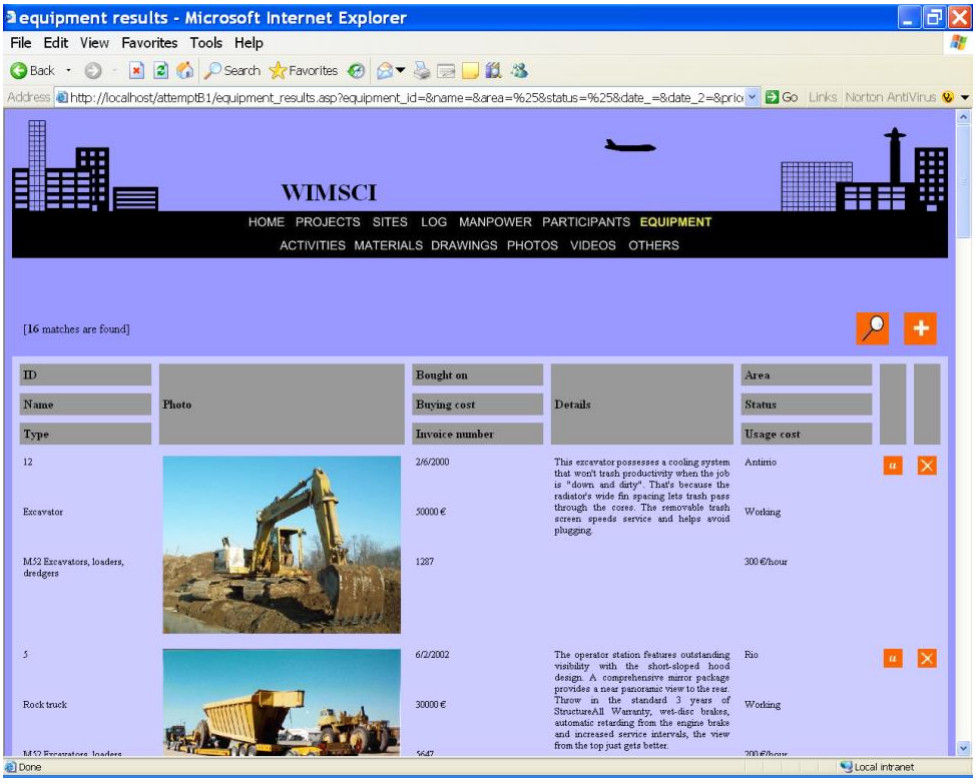

Figure 4: A typical Results Page of the Web Application

3. Conclusions

Project monitoring is an important element of efficient construction management. However, effective monitoring has been hindered by the dispersed locations of construction sites with the company headquarters, the large amount and diversity of related information, and the wide variation of participant specialties and computer acquaintance. In order to improve the efficiency of project monitoring, this work has proposed an information management system which utilises internet and database technologies. The system consists of a relational database and a web application that allows end users to remotely interact with the database. The database consists of 33 tables with a total of 164 fields. The database design followed an analysis of the information necessary for construction project monitoring and the typical project participants. The web application includes a set of data-driven dynamic web pages through which the user can interact with the database and perform certain actions, such as inserting, searching, viewing, printing, updating, or deleting data. The access to the database is controlled with usernames and passwords. The database was implemented using MS-Access 2003 while the web application was built with Macromedia Dreamweaver MX. The system implementation has used ASP (server technology), VBScript (programming language), and IIS (web server). The experimentation with the system has shown that the system can contribute to effective information management providing concise information, quick/remote access, prompt updating capabilities, and information reliability, facilitating thus the project monitoring process. As a result, time and cost savings, as well as higher construction quality can be expected.

4. References

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