Efficient Support for Mobile Computing on Construction Site

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ABSTRACT: Today's information exchange in managing projects are to a great extent supported by information technology. Especially mobile computing potencials can significantly improve the information exchange in construction. This paper addresses some important mobile computing potencials which can help tackle project collaboration and information dissemination problems. Special attention is given to the organizational and mobility issues of construction projects which must be considered by implementing mobile computing in construction. The final objective of the paper is to show why should be further research on mobile computing more focused on identifying the weaknesses of the present project information exchange procedures and their optimisation according to the applied IT in order to employ all of its advantages.
The paper, however resides on practical experiences, which have been accurnulated through a series of experimental projects called e-site.

KEYWORDS: construction site, mobile computing, project communication

1. INTRODUCTION

In recent years, the emerging information technologies e.g. mobile computing have significantly affected business processes and workflows. This has been demonstrated through the increased need to access useful information at any time and any place, creating information and sharing it with colleagues. Such information access showed its high value in terms of increased productivity, reduction of costs, faster communication and improvement of working conditions. In construction, information technology is being applied slowly compared to other industry sectors. One of the reasons repeated in many papers and reports is that the construction industry has to build its products under circumstances not convenient for appropriate IT support: the fragmented nature of the construction industry [Howard], uniqueness of products, vast number of companies and actors included, etc.
On the other hand, we are faced with another paradox. Currently, many engineers are still using tools that are far from state-of-the-art, and they are very reluctant to change tools. This situation lends itself to the complexity of engineering information structures today. Existing processes could be rendered much more efficient by altering older information structures to support newer ones, and rethinking our current philosophy of computer use [Rebolj]. Despite the availability of hardware systems and high speed wireless networks, we are still lacking software systems designed to support specific on-site tasks, provide helpful guidance through these tasks, and support intelligent methods of human-computer interaction that take into account the context of on-site construction and supervision activities [Menzel].
After conducting a series of experimental projects, called e-site, we obtained a firm belief that mobile computing extended information systems, present one of the possible solutions to improve Construction Information Technology, thus providing appropriate information flow in the life-cycle of a building product.

2. POTENTIALS OF MOBILE COMPUTING IN CONSTRUCTION

The term "mobile computing" or "ubiquitous computing" has no clear definition, although some studies have already tried to survey this fast-growing area of information technology. Mobile computing does not only involve mobile computing devices (such as laptops, notebooks, PDAs and wearable computers), which are designed to be carried around, but also the mobile (which in practice means wireless) networks to which these computers are connected. Specialized

services are the third component, rounding out the definition of mobile computing.

Although the number of research papers addressing mobile computing is modest, there is no doubt that a great deal of research is still going on, perhaps even too fast for papers to be published. In the field of civil engineering, interesting reports can be found, most of them are specialized on a specific task: for inspection - oriented applications [Garett], for recording activities on a building site [Menzel K.] etc.

Two main aspects exist when looking at any system: the partial and the holistic aspects. In construction this aspects can be defined as "company view" or "project view", and "personal view" or "actor view". In both aspects, mobile computing can significantly improve the efficiency of information flows or of information systems. Thus, we have to be aware that mobile computing implies the following facts:

- a mobile computer is bound to a specific person
- the location of a mobile computer can become a significant piece of information
- the mobile computer (and thus the person) is available anytime, anywhere
- the person has access to the system anytime, anywhere

These facts are of utmost importance and the basis for the core potentials of mobile computing in construction.

From the company (or project) view any information system in use can improve as follows:

- information system boundaries extend to the maximum, which means that information will flow to and from the destination/origin points without delays or obstacles
- additional information is available from terminal points, like their position, user ID, temperature etc.; in other words, terminals can help applications to become context sensitive

From the personal view following improvements are significant:

- the person can be available anytime, according to her/his role in the relevant projects
- any other actors in relevant projects are available
- personal communication can improve significantly through automatic selection using context parameters (date and time, location, activity etc.)

Based on these potentials we started to built a concept of a personal communication network by measure of the human – the actor – involved in various project and tasks (Figure 1). From the aspect of a project, this means a much smoother flow of information and thus a higher level of quality.

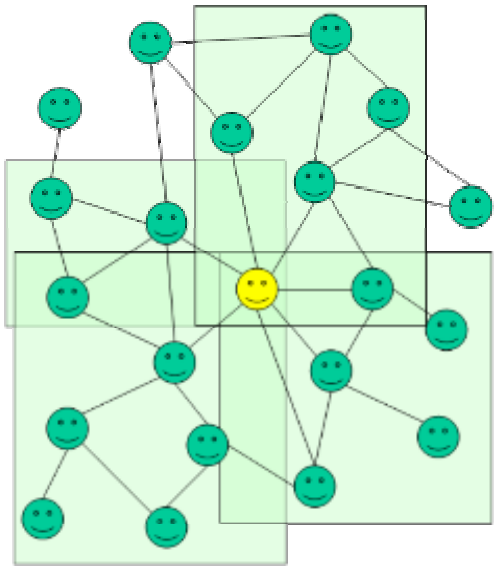

Figure 1. Personal communication links – People can work "closer" to each other in terms of more direct communication, organization can become structured on a single level.

Other details of concept are outside the scope of this article and therefore not presented. Instead main experiences as a basis for concept gained through a series of experimental projects called e-site are described and demonstrated.

3. STUDY

In autumn 2000, a multipurpose experimental-educational research project called Mobile Computing at a Construction Site (or e-site, for short) was launched at the Faculty of Civil Engineering of the University of Maribor [Rebolj D.]. The project has been conducted by the Construction IT Centre and carried out by students and engineers from the construction industry. The purpose of the project has been to answer the open questions of how mobile computing works on site, what organizational changes are required, are the common commercial mobile phone network services sufficient for mobile computing in construction, how complex is the problem of integrating mobile computing into existing information systems (which are still not integrated to the desired extent themselves), and what educational efforts will be necessary.

Simple and effective mobile document management system based on the study results has been designed and tested to demonstrate systematic use of mobile computing especially on construction site (Figure 2).

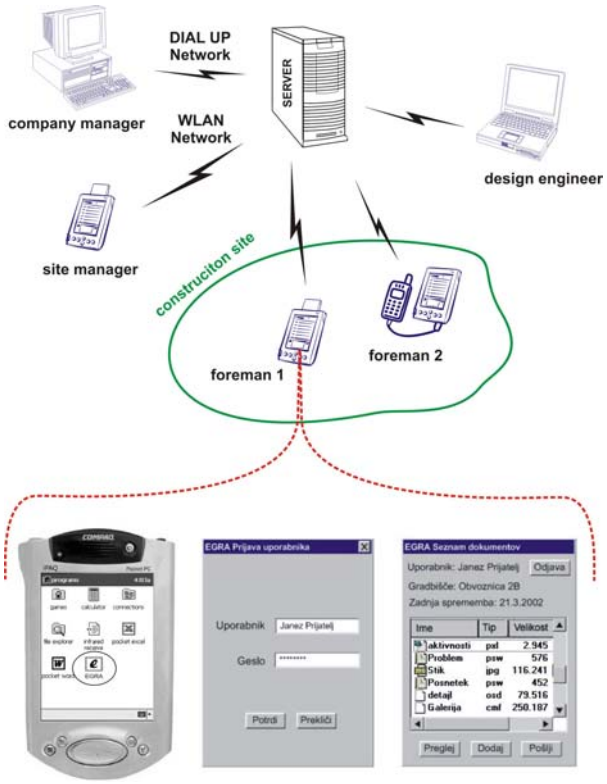

Figure 2. Prototype of mobile document management system

The system offers the following functionality: password-protected projects with multiple directories, each containing a flat set of files, every directory is linked to a list of users, each of whom has an electronic address for system messaging purposes (e-mail or mobile phone number for SMS messages), uploading and downloading files, activating software for supporting file types, alerting users to file changes in their directory (each message contains the time and type of change, and the name of the user who made the change).

The system demonstrations were performed according to the process shema of participating practice partner to directly show how the data flow could become fully automated and how to connect project members of all hierarchal levels with support of mobile computing.

The final test, carried out in 2001 (Figure 3), showed that the efficiency of information exchange in construction, between the construction participants and within the construction site itself, can be improved significantly even by using current mobile computing components: unmodified, available PDAs, mobile phones and other existing wireless networks, and web services. This project has been continued in 2002 [Magdic] and in 2003. The results proved the high potential of mobile computing for the construction industry.

Figure 3. E-site – experimental - educational research project.

3.1 Construction process optimization considerations

3.1.1 Organisational issues

The implementation of mobile computing into construction practice has demonstrated its advantages in many ways. Better information and communication flow, enhanced performance, higher productivity and other features enhance the possibilities for a successful accomplishment of project goals. On the other hand, there are several reports which elaborate on the weaknesses of the present system relations within construction sites and on the problem of poor on-site management disputes and various mistakes in design and on-site applications [Horner]. In addition, further research on organisational issues in the construction industry has revealed that construction is very unsympathetic to changes of internal organisation despite obvious environmental changes in the last few decades [Radosavljevic].

It has been shown that proper attitude towards the organisation within companies can reduce costs, increase labour productivity and hence make construction a much more profitable industry.

These were achieved by merely altering the way of managing the organisation [Radosavljevic M.]. However, the emerging experimental on-site mobile computing projects show that mobile computing represent for management an efficient tool to make internal flow of information more reliable and faster.

It seems there is a two-fold information flow in construction, namely: an official flow of documents (progress reports, cash-flow reports, survey reports, daily plans, etc.) and an informal communication between different levels of management regarding work progress, quantities, cash flow and on-site problems that is often interrupted and highly hierarchy-dependent. While regular, complicated procedures of inter-organisational submission of documents are well-accepted in construction, the well-trained eye could easily detect the disadvantages of these procedures. The documents are submitted hierarchically, irrespective of the speed of the process and they are required to follow specified paths instead of taking effective and legal shortcuts.

This further discloses that to a certain degree some information is hidden from most participants, despite the necessity of fast and effective information exchange between a construction site, investors, headquarters and all others involved.

For instance, a foreman receives the information from the operative plans once already on-site, in the form of daily activity plans. With the exception of a site manager, other participants (project manager, investor, head-quarters, etc.) receive information on daily activities several days or even weeks later. Similarly, foremen do not have particular instructions on whom to contact when disruptions or delays occur. This is more or less left to a foreman's personal discretion. However, in order to apply mobile computing to establish appropriate document paths, the communication possibilities need to be restricted. This restriction appears to contradict the basic purpose of mobility which is free communication. Often, a free (or informal) communication is the one that contributes to the project's success. If it is not effective, it may cause delays and disruptions and result in financial losses.

Mentioned limits should only be project-wide, enabling all participants to be permanently, actively involved (even if they are not physically available). When dealing with a specific on-site problem, foremen should be able to contact not only the site engineer but also the other partners, including designers, planning engineers, R&D specialists, the supplies department, etc. according to the nature of a problem.

Implementation of mobile computing enables this kind of free communication instantly, but the question remains whether companies really aspire such a free flow of information. It is reasonable to assume companies will approve of this free communication, because it results in better performance, more satisfied clients, higher productivity and traceable responsibility.

3.2.2 Mobility issues

In current projects we are focusing on different issues of mobility. We are observing mobility from the perspective of terminals and users [Piere]. The terminal is mobile if it can be successfully located and identified when it is carried around. At the same time it should provide access to telecommunication services from different locations.

User mobility is a different concept from terminal mobility. Here, the types of devices to access information are not important. Terminals can be shared among users and users can access the same services through different devices. However, it was found that customization of services has not reached an appropriate level yet. Here we have in mind broadly available and not specially designed applications. Users should be able to access the same service – application and information from different terminals and at different times. A great deal of progress needs to be made in this area. It is almost impossible for inexperienced users to change devices and access different services because of high service connection and data manipulation overhead. We see very common and simple solutions using web and HTTP and FTP protocols as highly desirable in this context. However, available services should better adapt to a variety of devices available, and thus provide better interaction with a broad user audience.

4. CONCLUSION

Within this paper the authors described how mobile computing technology might contribute to improve information exchange in construction.

It may be expected that mobile computing components (mobile devices, mobile networks, mobile services) will develop quickly, thus improving efficiency of mobile computing in the construction field even further. On the other hand,

information systems supporting engineering processes will have to be redesigned and improved so as to attain a higher degree of information integration and a higher efficiency of information flow.
In this respect it is very important to have at least an organization-wide policy of mobile computing use that includes standardization of procedures and infrastructure. Implementation should inevitably include process improvement efforts.
Anyhow, it is obvious that mobile computing already play an important role in the development of construction processes.

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