MOBILE COMPUTING IN CONSTRUCTION MANAGEMENT

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O**bjectives:** In this paper the author analyses how Mobile Computing can improve the management of the construction companies by providing better control over their business.
Prior Work: Although mobile phone based construction management tools already exist in Japan, North America, the Commonwealth and some European countries, they are inappropriate for the Romanian construction sector.
Approach: To address this issue, the author developed a web-based solution for smart phones and PDAs which addressees both bidding and the tracking of work progress, according to Romanian regulations in constructions. This solution extends the functionality of a desktop cost estimating program which allows data that is input in the office to be uploaded to a web server in order for it to be accessed by mobile devices.
Results: Early results of the pilot phase indicate a good acceptance of this management tool among its users.
Implications: The management tool proposed in this paper provides the following benefits: 1.Keeping managers informed with up-to date information of the status of the site work; 2.Increasing the accountability of the personnel in the field; 3.Reducing time-consuming paper work.
Originality: Since current research indicates that there are no other instances of this type of applications in Romania, the tool developed by the author may be the first of its kind in this country.
Key Words: construction management mobile computing smartphone PDA.

INTRODUCTION

Stiff competition and an unpredictable economic environment challenge the managers of construction companies to be both fast and accurate. Most constructors have faced situations where bankruptcy affected their main supplier, their subcontractors, or even their clients; or they have had to face considering hiring a subcontractor instead of continuing a certain job.

In such situations, the key to making the most informed decisions possible is to provide managers with accurate and timely information about their companies.

However, "accurate and timely" implies collecting data right at the construction site during the completion of jobs by using electronic equipment, and this requires overcoming some specific challenges of this sector. In this paper, the author discusses aspects of collecting work progress data at the construction work sites by using small form-factor computing devices such as PDAs and smart phones which are connected wirelessly to the Internet.

ASPECTS OF COLLECTING DATA AT THE CONSTRUCTION SITES

When deciding to implement a data collecting system at the work site, the managers and their IT staff have to consider the expected benefits, the type of equipment, and the type of the application.

Expected Benefits of On-Site Electronic Data Collection

The traditional paper-based system usually implies that foremen spend several hours filling in job-progress forms at the end of each month. A three-to-four week delay between the moment a certain operation was completed and the moment it was reported may affect the accuracy of the job-progress report since quantities or operations may be mistaken or forgotten in the meantime. At the office, data from these forms has to be manually transferred to the company's IT system, which is a time consuming and error prone process. Consequently, there are delays and bottlenecks in data handling that affect the overall efficiency of the company.

According to different studies and reports (ENR. 2005), an electronic data collection system connected to a data communication network can address these problems as follows:

- Reduces delays and errors by recording data immediately, right at the job site,
- Eliminates time-consuming paperwork done at the work site and in the office,
- Improves productivity by allowing foremen to focus on their work rather on the paperwork,
- Allows foremen to understand in real time the status of the job by comparing the actual quantities against the estimations,
- Reduces the non-billable time spent to bring paper forms at the office,
- Allows managers to know at any time the status of a job and how much money has been spent.

Choosing the Equipment

There are many factors to take into account when choosing the equipment, such as robustness, the form factor, and the price.

Robustness is important because the pieces of equipment have to endure mechanical shocks, dust, rain, and sun light. In this respect, the market offers so called 'rugged' devices, which provide all-weather protection and sunlight-readable displays.

The *form factor* is very important, and some studies show that "devices not fitting into a foreman's pocket will not be carried around, but rather left back at the site

office" [Magdic et al, 2002]. Other studies recommend that devices be single-handed operated rather than require two hands on a keyboard or using a stylus. [Bonar, 2007]
The *price* is also a relevant factor since a company can decide to buy twenty or more mobile phones for the price of a single rugged laptop.

The above aspects lead to the conclusion that it makes sense for a company to consider using handheld devices (PDAs) and mobile phones rather then laptops to collect data at the construction work sites.

Choosing the Mobile Applications

There are two aspects to consider when choosing the programs to run on mobile devices: the features of such programs and the implementation model.

Features to Consider When Choosing Mobile Computing Programs

In order to be efficient and be accepted by the users, a Mobile Computing (MC) application has to fulfill the following requirements [Bonar, 2007] [Leskinen, 2008]:

- To address users' needs exactly in the way they want,
- To integrate with users' existing information system,
- To be easy to use, and to offer "on-the-go usage without 'browsing' and single hand operation." [Bonar, 2007]
- To offer a consistent user interface across the variety of devices used on site

Implementation Models

There are two implementation models to consider for MC: *smart client* and *thin client* applications [Microsoft, 2004]

A *smart client* application shares the characteristics of a regular desktop application because it runs on the device and uses its computing power and memory. However, it requires periodic synchronization with a server to receive new data from the office and to transmit back data collected, as most of the time it works disconnected from the data network. Although fast and feature rich, smart client applications have the disadvantage of being device-specific, thus limiting user's options and also having higher prices.

Thin client applications, also know as "Zero Client Applications', are based on Internet browsers that access pages updated by a specialized web server, and offer the following advantages over the smart applications:

- Run on every device that can surf the Internet with a WAP compatible browser,
- Do not require pricey powerful devices since they only display data which is processed and stored on the Web server in real time,
- Have lower prices since browser based programs are easier to develop,
- Allow rapid deployment on all devices in the office and in the field,
- Offer a user interface consistent across different types of mobile devices.
- Are more secure since a lost or stolen device does not store sensitive data.

PREVIOUS WORK

There are many commercial products that followed the first implementation of Mobile Computing in Constructions (MCC) in the early 1990s [COMIT 2003]. For instance, DK Network, Japan [Magdic et al, 2002], JumpStart, USA [Bonar, 2007], BuildIT PRO, Canada [COMIT 2003], Buildercom, Finland [Leskinen, 2006], address the different aspects in construction management, from work safety to inventory and jobsite logistics.

MCC was also subject for academic studies and research. For instance, in early 2000s, researchers from the University of Maribor, Slovenia analyzed the potential of MCC [Magdic et al, 2002] and suggested a new way this technology could impact the internal organization of construction companies [Šuman and Pšunder, 2007]. Similar work was performed at Åbo Akademi University, Finland [Leskinen, 2006, 2008], which also took into account the business value of mobility. Furthermore, the business value of mobility and the need for a better method to evaluate the economic efficiency of MCC were studied at the Royal Institute of Technology, Sweden [Löfgren, 2007)]. An interesting approach is offered by a research paper at the University of Newcastle upon Tyne, UK [Chen and Kamara, 2008], which summarizes three types of site records (finance, quality and work progress), and groups mobile applications into three categories (Mobile CAD, Data Capture and Project Management Applications).

PROPOSED MOBILE COMPUTING MANAGEMENT SOLUTION

Based on the aspects presented above, the author designed and implemented a Mobile Computing Management system that allows foremen in the field to track their job-progress, compare it against the estimations, and send data back to the main office.

The main characteristics of this system are:

- It is Internet based, thus runs on any device that has a web browser. This implementation makes sense since Romania, the target market, has good area coverage for mobile telephony,
- It is integrated with an existing cost estimating program, also developed by the author, so that existing users do not have to invest in additional software,
- Allows data collected by foremen to be immediately accessed in the office,

- Allows single-hand handling and fast access to data, without much browsing,
- Enables access of data by the users according to their rights and roles. For instance, foremen can only access their projects and can modify only the job quantities in the current month; while clients can track the work progress done for their projects, without being able to change the quantities or to see other clients' data.

Implementation Details

Figure 1 represents a simplified schema of the system, where people in the office prepare cost estimates, update prices, etc. and then upload data on the web server. In the field, foremen keep track of the work progress by daily updating the quantities on the web server using their mobile devices. The web server is then synchronized back with the server in the office so that the managers can have permanently access to fresh data.

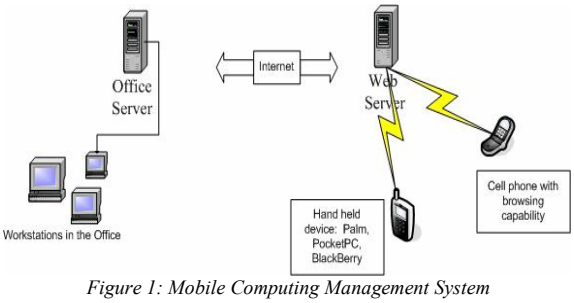

Figure 1: Mobile Computing Management System

Figure 2 displays several screen captures of the application running on a cell phone, where the left-most picture represent the main screen, the middle picture shows the project selection screen, and the right-most picture shows the recording of a job's progress.

This system is in the pilot phase, and future development includes automatic data transfer and a possible smart client version of the mobile application.

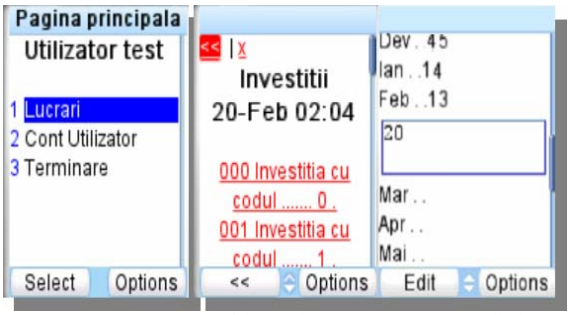

Figure 2: Screen captures of the application running on a cell phone

Once the system will achieve a critical mass of users, the author will be able to analyze several aspects, such as:

- Customer satisfaction,
- Profitability: quantify the profit increase of the clients and also the developer's revenue per client,
- Success stories: identify which are the factors that ensure the success of MC in construction companies and also understand the limits of this system.

CONCLUSION

Mobile Computing has the potential of improving the management of a construction company by using non-expensive web enabled mobile phones and a specialized web-based data collection system. Although its expected benefits range from eliminating duplicated work and errors during the processing of paper forms to offering the managers accurate and timely information about their business, it will be necessary to quantify the real efficiency of such a system in the Romanian market.

In this respect, the author will continue to develop and analyze a Mobile Computing application in order to gain enough data for a suitable interpretation.

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