APPLYING MOBILE DEVICES TO DATA GATHERING PROCESS IN REAL ESTATE MAINTENANCE

Kimmo Niemi

Institute of Construction Management and Economics, Tampere University of Technology, Finland

ABSTRACT: The purpose of this paper is to describe possible methods for electronic maintenance information design and management systems. With the help of mobile equipment, information on the target real estate can be gathered quickly and easily with a suitable method. When wirelessness is introduced, the user is directly connected in real time to the entire data bank of the organisation. Thereby the information is immediately available to all parties concerned. During maintenance, all procedures can be monitored and information about necessary repairs transmitted. In other words, mobile systems will be useful throughout the life span of real estate.

The research project introduced here is user-oriented not device-oriented. Its main objectives were to develop systems of sufficient usability and accessibility, which are not dependent on any specific mobile devices. The key is to find out which tasks can be done with small display and limited user interface.

KEYWORDS: real estate maintenance, data management, mobile devices, ICT

1 INTRODUCTION

The real estate business is increasingly considering the needs of end-users who have requirements for the premises. From this ensue that property owners are more interested in the well-being of their buildings. Properties can be far from each other so that on-site management is no longer possible.

Since the beginning of 2000 a "use and maintenance manual" for properties has been mandated by law in Finland. That was a step in the right direction even though there is still much to improve (The National Building Code of Finland 2000, Hekkanen and Heljo 2006). This paper is part of doctoral studies launched in 2001 aimed at creating methods for the use of mobile devices with the use and maintenance manual.

As Jones and Collis (1996) stated, computers have been used in the maintenance management process since the early 1970s. They performed a survey to find out the attitude toward computerized maintenance management systems in the mid 1990s. Up to 77 per cent of the respondents said that their systems needed further development. If the same survey was conducted today the percentage would probably be similar, because the demands have also increased.

Kirkwood (1995) claimed over ten years ago that information and communication technology (ICT) can help in maintaining the information on properties which is the most important asset of a facilities manager. Without accurate, up-to-date information, properties cannot be managed effectively and efficiently. He pointed out the potential of the Internet. The network has developed considerably since his claim and has now even greater potential.

On-site data collection with mobile devices from buildings in itself is nothing new. For example Pitt (1997) presented a condition survey method that uses a touch-screen based field data collection system. The basics of the system are very similar to the methods used in this study. The aim of this paper though is to describe the usability and accessibility of mobile devices as daily tools.

2 BACKGROUND

2.1 *Real estate maintenance*

Different sources divide building maintenance into three activities: corrective, preventive and condition-based maintenance (Horner et al 1997) or four activities: custodial, corrective, preventive and emergency maintenance (Rondeau et al 1995). The first division lacks two crucial elements: day-to-day housekeeping, for example cleaning, and corrective actions that must be taken immediately. The condition-based maintenance of the first category is included in the corrective maintenance of the second one. Even so, maintenance can be defined "as orderly control of activities required to keep a facility in as-built condition, while continuing to maintain its original productive capacity" (Korka et al 1997).

On the other hand the terms maintenance management and repairs and replacements refer to different areas of maintenance. (Rakli 2001). Also real estate management can be used as the blanket term for activity that covers of real estate maintenance and repairs and replacements (Tolman 2006a). Facility management is a wide concept as Chotipanich (2004) points out. This paper focuses on

maintenance and repairs and refers by real estate maintenance to activities aimed at securing the well-being of the building itself.

2.2 *Facility information*

The evolution of the Internet and the development of computer hardware have given a boost to computer aided/integrated facilities management (CAFM/CIFM) (Gabriel 2003, Gabriel and Ceccherelli 2004). They use the term "e-facilities management (e-FM)" and mention that it is becoming a catchphrase like e-commerce or e-business. They also describe the implementation of an FM information system (FMIS) based on CAFM/CIFM in a network of 600 buildings. That shows the efficiency of computer-aided data management over paper documents.

Tolman et al (2006a, 2006b) pointed out that storage of data and access to data are both important. They mentioned the historical background of paper documents and that product models have put information into electronic form. They suggested that wireless and embedded platform technologies may be solutions to real estate data management. Wireless technologies enable realtime data management which produces accurate information for decision making as implied by Kirkwood (1995).

Information models are used in building design to allocate structures like walls and windows, but also with building automation systems (BAS) as Schein (2007) told. He also mentioned that his model had not been tested as a control application, but that it would be possible to develop such software. These kinds of systems are ideal for maintaining information on the entire property. Every detail is in place and what is important: everything is accurate.

Intelligent building can be used as a term for advanced management and information management of buildings as described in different sources (Derek and Clements-Croome 1997, Pulakka and Himanen 2005). As Wang and Xie (2002) developed and tested a model for the integration of a building management system (BMS) and a facilities management system (FMS). Everything in the building is connected to a network: HVAC, lighting and even sensors inside structures. But until that becomes more commonplace, we need building surveys to know the condition of the property. Taylor et al. (2007) take the idea even further. They visualise a user interface of a 3-dimensional virtual building where all objects are usable. For example a drawer can be opened which contains archived documents.

2.3 *Building condition survey*

Then (1995) emphasized that condition surveys are crucial in prioritizing the maintenance workload. Without accurate knowledge of the condition of the buildings it is impossible to plan the use of money. This is why systems need to be developed to improve the collecting methods.

2.4 *Mobility*

Although this paper is not about telecommuting, the organizational and societal benefits apply to the mobile work described here as to the one described by Watson and Lightfoot (2003). They include increased productivity, time saving on travel and decreased traffic congestion. Unfortunately the drawbacks, such as high start up costs, also apply.

2.5 *Usability*

The work done by doctors and nurses is quite different from that of building service personnel, but the same type of information systems are suitable for both. Chen et al. (2007) designed a personal digital assistant (PDA) -based application for clinical practice and tested the satisfaction with it by a questionnaire. Its usability of got a rating of 4.69±0.90 on a scale of 1 to 5. That proves that a small display can be very useful.

3 MOBILE DATA SYSTEM FOR REAL ESTATE MAINTENANCE

The principal objective of the main research is to determine what kind of tasks in real estate maintenance can be done with portable equipment. The size and resolution of a display limit its capabilities. Real estate maintenance involves functions that require high-performance of the display. Yet, the usability of the systems is critical. The aim is to find highly usable methods, that really can hasten or otherwise help everyday maintenance work.

Figure 1 shows the examined process. The actual data system is somewhere in the network where it can be easily accessed by anyone needing it. The data storage itself is not defined in this research. Mobile users are connected to the data system via a wireless local area network (WLAN), general packet radio service (GPRS) or similar technologies.

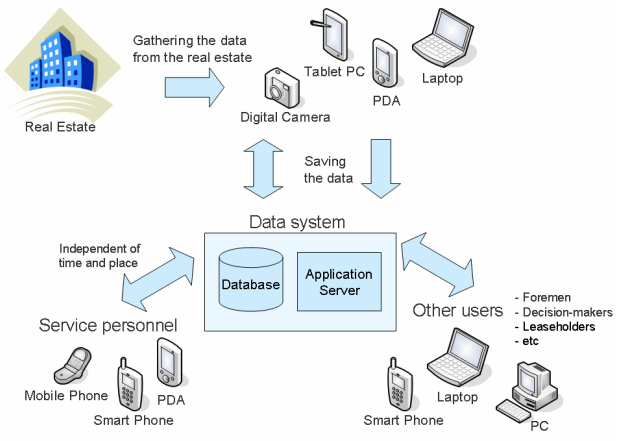

Figure1.

The following case in chapter 4 describes the empirical approach to the data gathering section.

4 CASE: BUILDING CONDITION ASSESSMENT

4.1 *Test arrangement*

The need for this study case was raised by a building survey professional. It also fitted in as part of the ongoing doctoral studies. The professional had conducted building surveys on a large number of buildings during 2002 and now it was time to do another survey for the use of long term planning. Earlier he used a laptop computer and a digital camera, which are very familiar equipment to all building surveyors. The used software was Microsoft Excel with self-made macros to help perform some basic routines. However, it was very difficult to carry the laptop in cramped places like HVAC rooms.

The actual study was to find out an easier method for data collection. The first task was to define parameters and there were five requirements for the equipment: (1) the device had to be pocket-size, (2) the battery had to last at least one full working day, (3) the display had to be visible in bright daylight, (4) its performance had to be adequate, and (5) it could not be too expensive.

4.2 *Device*

The personal digital assistant (PDA) was the natural choice. The selected PDA was Dell Axim X51v, which is powered by the Intel XScale PXA270 processor at 624MHz and has a 3.7 inch colour TFT VGA touch sensitive display with 640x480 resolution and 65536 colors. The system is packed with 64MB SDRAM and 256 Flash ROM. For data transfer there are CompactFlash Type II and Secure Digital card slots and integrated 802.11b WLAN and Bluetooth wireless technologies. It also has an integrated microphone and speaker. The PDA is easy to carry along because its only 119 mm x 73 mm x 16.9 mm and weighs 175 grams.

The operating system is Microsoft Windows Mobile 5.0 based on Windows CE 5.0. Windows Mobile is a compact operating system combined with a suite of basic applications for mobile devices based on the Microsoft Win32 API. It contains for example Office Mobile, which is capable of opening normal Office documents.

The display and battery were the reasons for selecting this device. The screen is legible even in daylight and the 1100 mAh battery pack lasts for 8 to 10 hours of hard use - with the 2200 mAh battery the operating time is even longer.

The first tests were conducted using Mobile Excel with the same templates as previously. The usability of Office Mobile Excel is not even close to its big brother and even the simpliest macros did not work. The time required for the work without the macros was almost double compared to working with a laptop, although the device was easier to carry along.

The next task was to create a system for gathering information. The system was designed based on the principles of usability studies, especially Nielsen's heuristics (Nielsen 1993). The primary aim was to develop a small system that was easy and fast to use. The resolution of 640x480 and especially the small 3.7 inch size were great limitations in comparison to laptop displays which are normally at least 12 inches with a resolution of 1024x768. All inputs were made with a stylus (a kind of pen), not keyboard and mouse.

4.3 *Data*

Gathered data has to be divided into categories. In Finland is used the Building classification system. The newest version is Building 2000, but in this case the previous version, Building 90, was used because it still is more supported by maintenance systems (Building 90). Table 1 shows an example of the classification. The system was designed as open, so it is not bound to this classification. Any classification that consists of a maximum of three levels will do. Classification can be changed by altering the definition file loaded at start-up.

Table 1. Example of Building 90 -classification (Building 90).

Building 90 classification
...
G Element division: Mechanical services elements
G3 Air conditioning services
G31 Air conditioning plant
G32 Elements of air conditioning units
G33 Ducts
...

4.4 *Data handling*

Because the Dell Axim X51v running Microsoft Windows Mobile was chosen, the development environment had to be Microsoft Studio .NET 2005, using .NET Compact Framework 2.0. The language selected was C#. Microsoft Studio .NET is delivered with a PDA emulator, which was used to test the system before field tests and to take the screenshot presented in Figure 2.

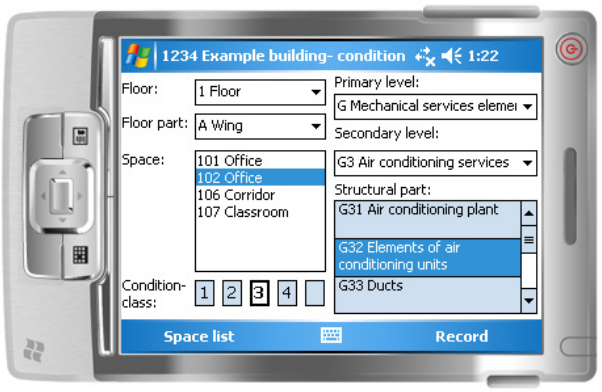

Figure 2.

Extensible Markup Language (XML) (Bray et al. 2006) was selected for saving the condition data. The definition file also uses XML language.

Data is input into the PDA only with a stylus, but a building surveyor often need to save additional data on a space. The stylus is too slow for that, which is why voice recording is used. The recorded audio files are linked to spaces using the XML file and are stored in WAV format.

4.5 *User inferface*

Because the system has to be easy to use, the principles were clear: all main functions had to be on one screen (see Figure 2). Space information is on the left and the category information on the right. The condition is selected by a number from one (new or almost new) to four (need urgent repair or replacement).

The system allows changing the information of a space via a space list, but because all the information was already in a maintenance system, it was exported and generated to an XML file.

4.6 *Material*

The building survey was conducted as a visual inspection. Table 2 shows the building mass surveyed. There were a total of 155 buildings in 10 real estates from all over Finland (figure 3) containing over 7 000 spaces with a total area of 170 000 square meters. The surveyd properties now were the same as in 2002.

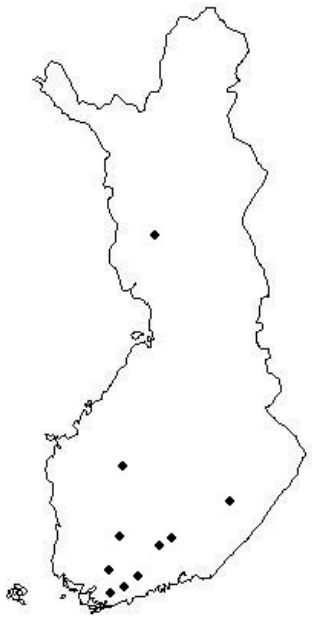

Figure 3.

Table 2. Key figures on condition surveyed properties.

#	Location of real estate	Number of buildings	Number of spaces	Average age (in 2006)	Area m^2	Volume m^3
1	Southern Finland	14	605	33,0	18 320	173 461
2	South Coast	11	575	25,1	15 522	105 528
3	South Coast	30	570	35,2	8 846	47 885
4	Central Finland	20	776	30,6	17 925	113 171
5	Northern Finland	3	580	21,7	18 268	85 755
6	Southern Finland	11	920	36,8	21 143	90 187
7	Southern Finland	13	488	24,4	7 629	29 974
8	South East	13	658	27,3	15 680	80 787
9	Southern Finland	6	429	51,3	9 156	39 320
10	Southern Finland	34	1 446	29,6	35 830	233 115
	In Total	**155**	**7 047**	**31,5**	**168 319**	**999 153**

5 CONCLUSIONS

No accurate measurements were made during this research because there was no detailed information from earlier survey, but it become clear that the mobile building assessment system does not consume more time. Nor does it save time, at least not much. However, it is much easier to use when for example, a surveyor has to climb a ladder to a roof. Research to resolve actual time usage is now in progress.

The doctoral studies started in 2001 with mobile phones and wireless application protocol (WAP). The development of mobile devices has been very rapid: resolution of the displays has increased, battery life has multiplied, connections are much faster, and the devices are smaller and lighter. The evolution of these devices is nowhere near the end.

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