Construction Progress Control (CPC) application for smartphones

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**Introduction**

Construction inspectors usually use notebooks or laptops to take notes on the construction site about how the tasks are progressing and any other relevant information. Later, when they are in the office they format this information and send it to the scheduler. This way of working wastes time and resources and could be optimized with a new technology already on the market: smartphones.

**Objectives**

The first objective of this work is to perform a literature survey to investigate if other researchers have already worked on connecting smartphones with construction planning and see what has been done. The second objective is to develop a basic prototype of a smartphone application to help in the planning and scheduling of construction, reducing the time and resources (notebooks, laptops, etc.) that are currently used.

By the date of writing of this report, the first two objectives have been accomplished. Due to the nature of the product (i.e. a piece of software) and of its environment (i.e. smartphones), smartphone apps are a very new technology and are experiencing a really fast development. Studying the market and the business possibilities of this product should start as soon as possible and if their results are positive, the development of a more complete application should be performed as fast as possible in order to be the first working group offering such a product to the market. It is predicted that similar products from other groups will appear rather rapidly when construction companies and software developers notice opportunities offered by smartphones.

A prototype called Construction Progress Control (CPC) was developed in four months. Developing a more complete application is expected to take about six additional months if performed efficiently.
Literature Survey

The most interesting works found in this literature survey are those by Vilkko et. al. (2008) [1] and by Nourbakhsh (2010) [2]. In both of them the authors have worked in a mobile application for monitoring the progress of the construction tasks from the worksite.

Vilkko et. al. (2008) [1] have developed a smartphone application which enables collecting and accessing precast concrete element data at the worksite, performing measurements and storing elements location. The strong points of their application when compared to CPC are that the collected information is accessible by project partners in real time and that they have tested the application in real world construction projects with promising results. The weak points are the need for good mobile phone network coverage (they planned to develop offline functionalities but still have not done it) and the system’s dependence on other external devices like GPS.

Nourbakhsh (2010) [2] has developed a much more complete mobile application that can be used by contractors and consultants in the construction industry. The strong point of his application when compared to CPC is the much high number of functionalities: his application allows the user to update schedules, report violations, report QC/QA problems, report accidents, report inspection results, access productivity information, access site instructions, change orders, record delays, take pictures of progress, etc. The weak points are the complexity of the application, the platform (Microsoft Windows Mobile instead of Google Android or iOS), the web-based interface and the dependence on Microsoft SharePoint services (licensed software).

The work of Yeh et. al. (2010) [3] is remarkable too since it can be the source of ideas for future developments of CPC application, although their work is not a smartphone application that can be compared to CPC. Yeh et. al. (2010) [3] have developed what they called iHelmet, which consists of a hard hat that integrates a projector and a tablet device (iPod). The idea is that on-site workers input their location to the tablet and they can access project information and construction drawings related to that location; this is projected to any smooth surface they look by using the projector on their hard hat.
In references [4] to [8], the authors study and discuss the main benefits and problems of using mobile IT on worksites in construction industry. In general they all agree that benefits of using information technologies (IT) to construction industry are known and well studied. The construction industry knows has already implemented IT in their offices. However, they have still not implemented IT on worksites as much as they could.

The main problem seems to be that few years ago, mobile IT in worksites implied using PDA devices, hand-sized computers with high cost, low functionalities and few developers. Nowadays, this has changed and PDAs have become outdated devices since smartphones have substituted them. Consequently, nowadays, IT on worksites means using applications on smartphones. That means low costs, high functionality, and many developers.
Discussion

The product developed in this work is a basic prototype smartphone application. This application should help schedulers in the construction industry to follow the progress of the different activities on a construction site using smartphones instead of traditional paper-based methods.

The main advantage of this product is saving time since there is no need to first take the notes of the status of the various activities, and later format this information and send it to the scheduler in the office. This product allows the inspector to record the status of an activity and instantaneously send it to the scheduler. Additionally, this product also saves resources since the work can be done with a smartphone that is used for many other tasks.

Before starting the development of the application, it was necessary to choose the most appropriate platform. The platforms that are currently available for smartphones include Android, iOS, Symbian OS, BlackBerry OS and Windows Phone, but the ones that are mostly used are Android and iOS (iPhone) with a market share in 2011 of 38.5% and 19.4% respectively [9].

The application was developed for Android smartphones because this platform has the highest market share in the world and because Android follows an open source philosophy; so it is easier to find examples of source codes for Android applications on the Internet and the development process can be faster.

There are three main parts in the working process of this application: acquire the data, edit the data, and send it to the office. This information will be used in the office to update the construction schedule and take the corresponding decisions if necessary.

Since the most popular software for construction projects management in the US is Oracle's Primavera Software, it was decided that this application should format the information of the project in an easy way to be imported to and used by Primavera.

There are different ways Primavera can import data, but the easiest to implement in the application was using Microsoft Excel files. The idea is that the user of the application records the information, the application formats it into an Excel file
and Primavera reads (import) the information from the Excel file and incorporates it in a file with Primavera's own format.

The same happens when the application acquires project information from Primavera but in the opposite direction: Primavera creates (export) an Excel file with project information and the application reads it and shows the information to the user in its own format.

Currently, the Excel files with the project information are transferred from/to the computer that houses Primavera via USB cable. In the future, these files will be transferred using the telecommunication capabilities of smartphones (e-mail, wifi, mobile internet, etc.)

Primavera allows the user to input a large variety of information related to a project like activities, relations between activities, resources, etc; but the objective of the application is to update the status of the activities of the project using a smartphone. Consequently, the application reads only the information related to activities and ignores any other information about the project. After reading the activity-related information from the Excel file exported from Primavera, the application shows to the user the name and information of the activity, the project to which the activity belongs, and the percentage of completion of the activity. At this time, the user is able to update the percentage of completion of the activity and also add some comments and pictures related to the activity. Pictures can be taken with the smartphone camera or selected from the files on the SD card of the smartphone. Comments and pictures are only for the information of the people planning the construction in the office, and not for Primavera. Primavera does not have to work with the comments and pictures because it is not able to do that. Primavera works with the updated percentage of completion of each activity as input by the user.
About Primavera

Primavera Systems is a brand name under which a range of solutions are marketed. Primavera was launched in 1983 by Primavera Systems Inc. and was acquired by Oracle Corporation in 2008.

The focus of Primavera enterprise project portfolio management (EPPM) software is to allow organizations to effectively manage their programs and projects. This means project management, collaboration and control capabilities, integration with other enterprise software (for example Oracle or SAP’s ERP systems), end-to-end real-time visibility of all corporate information to inform portfolio management decisions, determination of correct resources, management of individual project teams, etc.

Current Primavera EPPM software products include:

- Primavera P6 Enterprise Project Portfolio Management
- Primavera P6 Professional Project Management
- Primavera P6 Analytics
- Primavera Portfolio Management
- Primavera Contract Management Business Intelligence Publisher Edition
- Primavera Risk Analysis
- Primavera Inspire for SAP
- Primavera Earned Value Management
- Primavera Contractor

The one that communicate with the application developed in this study is Primavera P6 Professional Project Management.

According to Oracle's own words on its website, Primavera P6 Professional Project Management is a recognized standard for high-performance project management software designed to allow project managers and schedulers to handle large-scale, highly sophisticated and multifaceted projects. It can be used to organize projects of up to 100,000 activities, and it provides unlimited resources and an unlimited number of target plans. It allows management of massive data with flexible organization tools to provide a multitude of ways to organize, filter and sort activities,
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projects, and resources. Information about Primavera P6 and an example output are presented in Figures 1 and 2.

**Figure 1.** Primavera P6 Professional Project Management in Oracle's website.

**Figure 2.** Activities in Primavera P6 Professional Project Management
The application

To use this application, the user has to create an Excel file with activity information relative to the project. The user opens the project using Primavera P6 Professional Project Management and clicks on the Activities button (Figure 3). Then the user uses the Export option (in the menu File) selecting the Excel format "xls" (Figure 4) and the Activities information (Figure 5).

Figure 3. Primavera's main screen (click on "Activities")
Once the user has the Excel file with the activity information the Android smartphone (which contains the previously installed App) is connected to the computer, and the Excel file is transferred to the SD Card of the smartphone. The path
of the folder in where the application is going to read the file is usually the following one:

/mnt/sdcard/Android/data/cpc.application/files/example_excel_file.xls

When the file is in the indicated location in the smartphone, the user opens the application and selects in the main screen (Figure 6) one of the following three options: read the application instructions, update the status of the activities, or add pictures of the activities.

![CPC Application](image)

**Figure 6. Main screen**
As seen in Figure 7 the instructions page presents a brief guide to this application.

**Figure 7. Instructions**

Instructions:

1. You have to open your project in your computer with Primavera software, and select the Export option in the File menu to create an excel file (XLS) with the Activities information of your project. This excel file must have the exact configuration* that this App can read.

   (Use the button below this instructions to create an example file with this configuration)

2. You have to rename your excel file with the name example_excel_file.xls and place it in the following folder of your Android smartphone:

   `/mnt/sdcard/Android/data/cpc.application/files/example_excel_file.xls`

3. In the main screen of this App you have to press the button 'Update status of an activity' and you will be able to update the status of the activities of your project and add comments

4. In the main screen of this App you have to press the button 'Add picture of an activity' and you will be able to add pictures of the activities of the project
When the user clicks on the "Update Status" button on the main screen (Figure 6), a new screen (Figure 8) allows the user to see a list of the different activities in the project, select one of them, see information about the selected activity, update the percentage of completion, and add comments.

If the user clicks on the "Add Picture" button on the main screen (Figure 6), a new screen (Figure 9) allows the user to select one of the different activities in the project, and add pictures by using the smartphone’s camera or by selecting the files.
Once updating the activity status is completed, the smartphone is connected to the computer and the appropriate folder (in the path that was previously mentioned) that contains the Excel file and the pictures is accessed (Figure 10) and imported to Primavera. Primavera ignores the comments and the pictures, but uses the updated percentage of completion to rerun the schedule.
Figure 10. Transferring the updated Excel file and the pictures from the smartphone to the computer
Following the same process in exporting activity to the application, the user selects the Excel format ".xls" (Figure 11) and "Activities" (Figure 12) when importing updated information from the smartphone.

**Figure 11.** Primavera’s Import dialog (select the Excel format, ".XLS")

**Figure 12.** Primavera’s Import dialog (select "Activities")
Conclusions

The main conclusions of this study that involved the development of a prototype application are:

- Smartphones and applications for smartphones are new technologies that are currently having a high growth rate and a fast rate of development, extensively impacting almost every part of modern society [10].

- There are many opportunities for using smartphone applications but the construction industry has been slow noticing these possibilities.

- Applications can be developed in a very short period of time and may need frequent updates. Success in this business is dependent on quick development and on correctly identifying the needs in the industry.

- Commercialization of this application could be very profitable and should not be very difficult if the application is ready before any other similar application appears on the market.

- There are no publications of works in similar apps in the main construction journals at the moment of writing this document.

Possible future works

The most interesting extensions to this production the near future could be:

- Possibility of sending and receiving the project information using telecommunications instead of USB cable.

- A market study can be performed and a business plan can be drawn to see how profitable this application could be. If these studies suggest the application could be profitable enough, funding can be sought to develop a more complete version of the application and commercialize it.

Thinking in a longer term it would be good idea to take under consideration also the following possible works:

- It would be desirable to have the application available in both Android and iOS platforms but since we are now in the phase of developing a prototype and we needed to be as fast as possible to avoid other people creating the same product before us we had to choose only one platform (Android). In the long term,
creating a full version of the application for other platforms like iOS is highly desirable.

Bibliography


[7] Xiaolin Li1; Deping Liu2; and Liqiang Yang (2008). "Research on the Application of Mobile Communications Technique in ITS". "Logistics : The Emerging Frontiers of Transportation and Development in China". Publisher: American Society of Civil Engineers

http://www.gartner.com/it/page.jsp?id=1622614 accessed on 08/05/2012.

[10] "Gartner Says Worldwide Mobile Phone Sales Grew 35 Percent in Third Quarter 2010; Smartphone Sales Increased 96 Percent".
http://www.gartner.com/it/page.jsp?id=1466313 accessed on 08/05/2012.
Appendix: source code

This appendix contains the source code of the files created for this Application. These files were developed using Eclipse IDE for Java Developers (version Indigo Service Release 2) with the plug-in Android SDK Manager. This plug-in was used to create an Android Virtual Device (with 2.3.3 version of Android operating system) in which the Application was tested and worked fine. Additionally the Application was tested in a real Android device (Sony Ericsson Xperia Arc Pro MK16A) with Android 2.3.4 version of Android operating system. The Application worked fine in this real device too.

Following are listed the several files created by the developer for this Application. To edit the Application, all these files should be placed in their appropriate location in an Android Project in Eclipse.

Furthermore, it is also necessary to download and add to the Build Path of the project a library in order to allow the Application working with Excel files. This library is called "JExcelAPI" and can be downloaded from the following open source website: http://jexcelapi.sourceforge.net/

To obtain the compiled file of the Application, the project should be executed by Eclipse as an Android Application. Then the compiled Application file can be taken from the "bin" folder of the project with the ".apk" format. That file can be transferred to a real Android device and installed.
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