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Automated Field Material Procurement using Pocket PCs

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Abstract

In the construction industry, materials account for a big part of products and project costs. The total cost of installed materials (or *Value of Materials*) may account for 50% or more, even though the manufacturing cost may be a minor part of the total, probably 20-30%. Material ordering and delivery are very important for the successful execution and completion of any project since unavailability of materials can stop production. The person in charge of procuring materials needs to ensure that the correct materials in the correct quantities are ordered. They also need to verify the release dates at which the material is needed and clearly specify those delivery dates as well as the location of delivery to the supplier. It is important for a company to consider that even for standard materials, there may be significant difference in the date that the material was requested or date when the purchase order was made, and the time in which the material will be delivered. Unavailability of materials when needed can affect productivity, cause delays and possible suspension of activities until the required material is available. These delays can occur if the quantities needed are large and the supplier is not able to produce those materials at that time or by any other factors beyond the control of the company. Therefore, material procurement is a critical aspect to consider for the successful completion of a construction project. Current material procurement practices in the construction industry are mostly paper-based. This method requires double entry of information, which could increase errors. In addition, report dissemination among the different parties could be a challenge. The paper presents a research effort to automate the current material procurement process, using the Pocket PC platform, for the electrical construction industry. This effort seeks to improve the current manual process and to minimize errors.

Keywords

Material Procurement, Supply Chain, Electrical Contractors, Information Technology, Automation

1. Introduction

The successful completion of any construction project depends heavily in the daily progress of the work, which in turn is dependent on the availability of resources and equipment, particularly of the materials required to complete the project. Materials not only impact the total cost of the project, but, in addition, they are a deciding factor in the progress of the work as the absence of material can cause delays. Current material procurement practices in the electrical contracting industry are mostly based on paper forms. The time spent in filling and distributing the forms can be extensive and prone to errors due to duplication of entries between the various forms, a factor that motivates the purpose of this research.

The recent advancements in Pocket PC technologies allow the development of a complete solution in an attempt to automate the material requirement process for the Electrical Construction (EC) industry. The use of Pocket PCs allows for data collection in digital format which minimizes the use of paper forms, thus eliminating duplication of manual entries. In addition, because the data is digitally input and recorded, this allows for a faster data distribution among the parties that need the information. The article presents a research effort to automate the current material procurement process in the electrical construction industry to improve the process of data collection and transfer. In addition, the development of the application seeks to minimize the use of paper forms and the errors associated with double manual entries, difficulties in understanding other person's handwriting and report distribution.

Material Procurement in the EC Industry

In the electrical contracting industry, material procurement is very critical to the successful execution and completion of any project. A previous research effort by the authors (Perdomo and Thabet (2002). Thabet and Perdomo (2002), J., and Thabet and Perdomo (2001)), has investigated the current material management practices in the EC industry. The person in charge of procuring materials, or the purchasing department in the case of a large company, needs to ensure that the correct materials in the correct quantities are ordered. They also need to verify the release dates at which the material is needed and provide the supplier/distributor with clear instructions on where to deliver. Once a supplier is selected, the contractor has to systematically follow up the status of ordered material in order to assure that the material arrives to the job site in the quantities and dates specified. In many companies, this process starts with the generation of a material requisition schedule.

The purchasing process is different depending on the types of material ordered. Although the purchasing process may involve negotiating specifications and prices directly with a manufacturer, electrical contractors need to purchase materials from a supplier/distributor. The selection of a reputable supplier is critical for ensuring that materials are delivered in the quantities needed and at the dates specified. Some companies have independent agents, depending on the type of material, for supplier selection and procurement. Suppliers are usually selected based on the lowest price. However, contractors may consider suppliers with higher prices that will provide better service or that have a record to supply the right material in the quantities needed at the times specified. In some situations incomplete proposals from suppliers may delay the selection process.

For miscellaneous materials or commodities (e.g. cables, wires, conduits, etc.), most contractors select their suppliers/distributors based on a bidding process, unless there are blanket purchase orders or yearly contracts for certain types of commodities. In this case, the contractor buys those commodities from that particular supplier. Due to high competition in their market area, some contractors don't use blanket or yearly contracts because they are able to get competitive prices by requesting bids from their suppliers at any time.

For major material (e.g. panels, gears, etc.), it is very common that the contractor negotiates prices with the manufacturer, if the manufacturer is specified in the contract documents. If the manufacturer is not specified in the contract documents, the contractor requests bids from different manufacturers. However, the contractor has to buy the material through the supplier/distributor after a mark up has been applied. Typically the contractor requests prices or bids for the amount of material that was originally estimated. Contrary to miscellaneous material, major material needs to be fabricated and requires lead times. If the amount requested is less than the amount estimated and there are shortages, the contractor will have to wait until the material is fabricated, which can cause disruptions and delays.

Typically, after the contract has been awarded to the supplier, an agreement is set by the issuance of a temporary purchase order. This temporary purchase order assures the supplier that the contractor will buy

the material from that particular supplier. After the contract is awarded, the supplier issues submittals, for major material and certain miscellaneous material to the electrical contractor. Once the submittals have been approved by the engineer/owner's representative, the temporary purchase order becomes a purchase order and a contract is established between the supplier and the electrical contractor.

Material Requisition Process during the Construction Phase

Material requisition problems greatly affect the construction stage and failure to manage this phase effectively could result in project disruption and possible delays due to late deliveries, stockouts due to small quantities bought, material delivered to the wrong locations, material backordered and effects in overall costs. The requisition process for miscellaneous material starts in the construction phase and is focused on how much material to buy, when to buy this material, where to deliver this material, when to deliver, which supplier to buy from, where to store on site. The decision of how much to buy is very important to assure that the quantities needed are available and that there are no material shortages. The decision of when to buy is important to ensure that material is available when needed. The decision of where to deliver the material requires space planning and consideration of site limitations, pre-fabrication strategies, and subcontractors to be used. This decision should be made to minimize theft, loss and damage and at the same time considering availability of material when needed. The decision of when to deliver requires knowledge of the schedule and actual installation rates. The decision of which supplier to buy from depends on contract agreements, specifications and performance of the supplier. The decision on where to store on site depends on site restrictions and space availability.

Various interviews were conducted by the authors to investigate the different approaches used by the electrical contractors to request material during the construction phase. Based on literature review and interviews, the process starts with the generation of material release forms by the foreman or the project manager. In this form, the material needed, quantities and the dates when the material is needed are specified. The foreman sends the form to the project manager, who is in charge of requesting the material from the purchasing department. The purchasing department requests the material from the supplier and instructs the supplier about material type, quantities, time when the material is needed and instructions for delivery. Fig. 1 depicts a typical material requisition process for miscellaneous material for an electrical contracting company.

(Step-1) Whenever materials are needed at the construction site, a material requisition process is initiated by site personnel (e.g. foreman or the project manager). The process involves the generation of a stock requisition form. In this form, the material description, quantities needed, dates when the material is needed, and material cost codes are specified. Other information specific to the job including personnel names and phone numbers, job address and ID, date and signatures are also included when filling the requisition form. The PM also includes a contact name and phone number of a designated site personnel in charge of receiving the material ordered when it is delivered to the site. Once the form is completed manually, the PM sends it to the purchasing department.

(Step-2) The PM updates a material release summary form, based on the new order completed (Step-1). The purpose of this form is to keep records of the material being used in the project and the balance available for requisition. A copy of the summarized releases is sent to the foreman.

(Step-3) The purchasing department requests the material from pre-selected suppliers/vendors and instructs the supplier/vendors about material type, quantities needed, time when the material is to be delivered and instructions for delivery (i.e. location and contact person). The purchasing department forwards a copy of the stock requisition form with this information to each supplier/vendor. Material is generally requested for delivery to the jobsite. In some instances this may not be feasible due to storage or access limitations. In this case, the material is delivered to other locations such as the contractor's

warehouse or another subcontractor storage area. Some companies utilize a pre-fabrication shop facility to assemble components in a controlled environment.
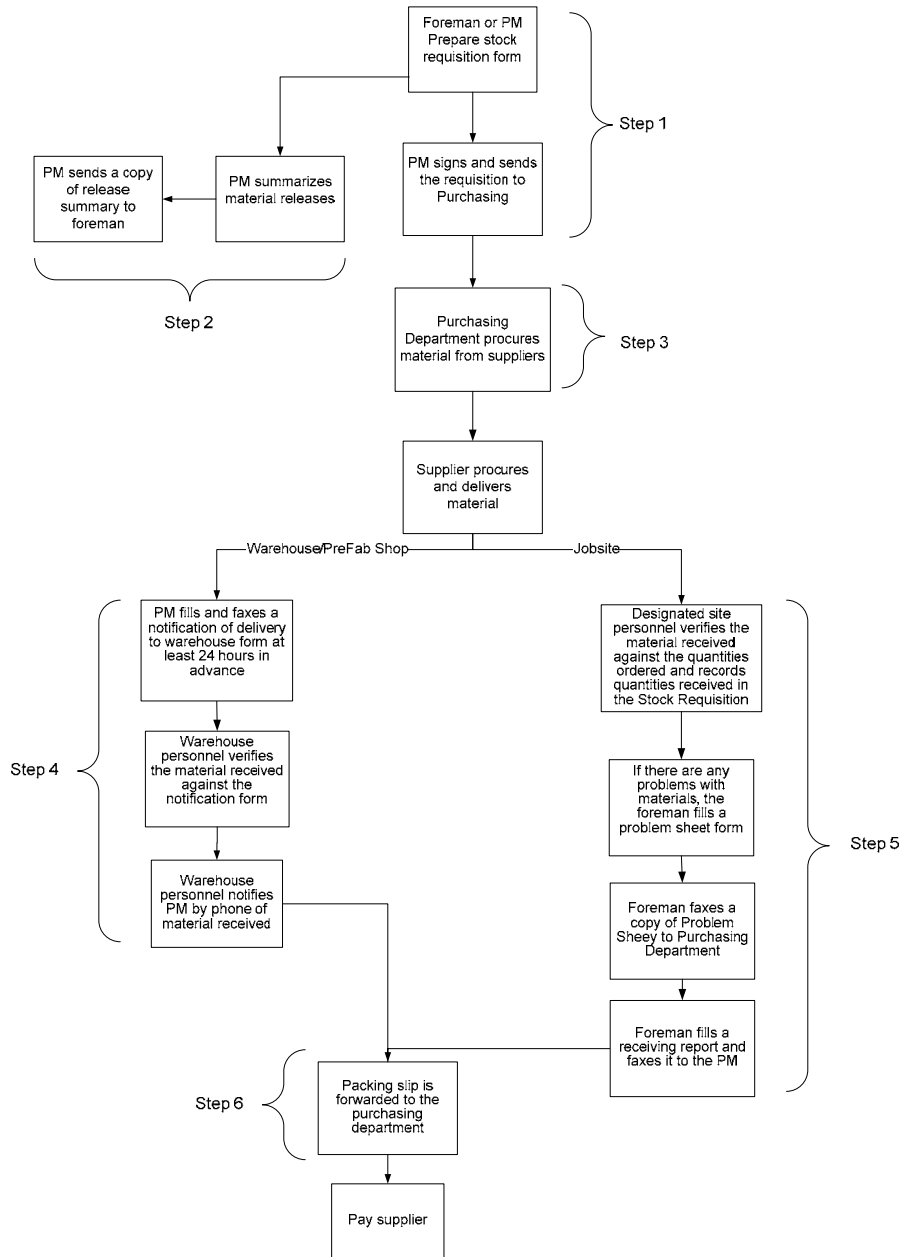

Figure 1. Material Requisition Process for Miscellaneous Material.

In other instances, the electrical contractor may utilize a subcontractor's yard for storage and subsequent delivery and installation.

(Step-4) In the case that the material is delivered to the warehouse, the PM fills a notification of delivery to warehouse form to notify the warehouse personnel that certain material will be delivered to the warehouse for storage. This form specifies the type and quantity of material to be delivered, when it will be delivered, job number, supplier/vendor's name, carrier name, and holding period for the material. This form should be prepared and sent at least 24 hours in advance of delivery. Once delivered, the warehouse personnel verify the material received against the notification of delivery to warehouse form and stamps

the packing slip for acknowledgement that the material was received. The packing slip is forwarded to the purchasing department for payment purposes. If there is any damaged material, it is noted on the packing slip and the purchasing department is notified. The warehouse personnel also notifies the PM by phone of all material received and stored at the warehouse.

(Step-5) In the case that the material is delivered to the jobsite, the designated site personnel verify the material received against the stock requisition form. Actual quantities received are recorded in the received column in the requisition form. If there are any discrepancies in material quantities, damages to material or items not delivered, the foreman fills a problem sheet form and forwards a copy of this form to the purchasing department. At the time that the material is received, the foreman also fills a receiving report and forwards this receiving report to the PM.

(Step-6) For payment purposes, a copy of the packing slip is faxed to the purchasing department, from the warehouse or the site, for acknowledgment of delivery of material and payment purposes.

Figure 2 illustrates a summary of the information flow between the forms used in the requisition process. The stock requisition form is the base form used to input information into the other forms. This information transfer between forms is done manually, which requires double entry. The process is time consuming and prone to error due to the manual input of data. From the stock requisition form, the material description and quantity requested in a particular period is input into the material release form. This form is used to keep track of the material ordered in each period and the remaining balance. If there are any problems with the material ordered (e.g. damage material, incorrect quantities) the site personnel writes the material description and the problem encountered into a problem sheet form. Most of this information is coming from the stock requisition form. When an order of material is received, a receiving form is filled. In this form, PO number, job number, job name, material description, and quantity received. All the information, except the quantity received, is obtained from the stock requisition form.
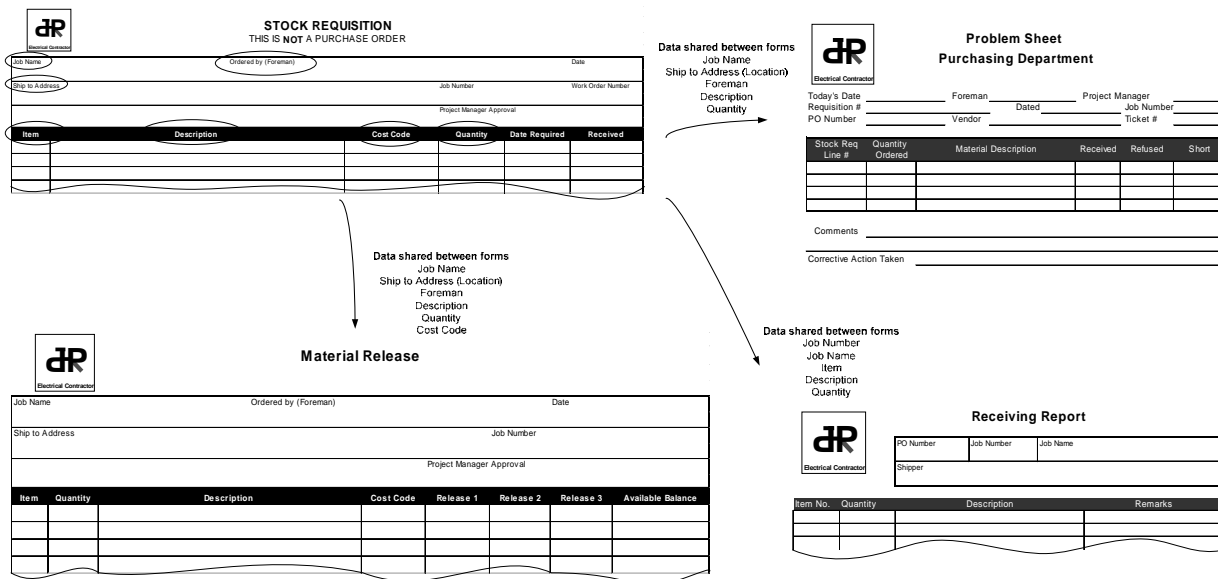

Figure 2. Information flow between the paper forms.

Proposed Automated Solution

We propose to automate the process of material requisition for the electrical contractor by using handheld devices, specifically Pocket PCs. We developed electronic versions, in the Pocket PC, of the paper based forms currently used for material requisition. These electronic forms contain all the information in the

paper forms considering the information sharing between forms as depicted in Figure 2. The proposed solution was developed in an iPAQ H3670 Pocket PC from Compaq. The iPAQ has a 64 MB of ram memory running Windows CE 2000.

The software used in the development was VisualCE from Syware. VisualCE allows developing customized applications. The user decides the information needed in the form, and then can create a customized form by dragging and dropping controls. In addition, the software allows synchronizing the handheld your device with the desktop PC. The application allows data sharing with software such as Microsoft Access, Lotus Approach, Sybase, Oracle, or Visual Basic.

The application is comprised by four levels in which the information needed and the forms used in the process are classified. Level 1 is the main menu of the application. Level 2 contains 6 modules: General information, Database Module, About, Help, Exit and Procurement Module. The most important modules are the Database Module and Procurement Module. The Database Module is comprised of databases that have all the information about Material, Personnel, Suppliers and Projects. These databases comprise Level 3. Level 3 also comprises the electronic versions of the paper based forms used. Level 4 is comprised by 5 databases, which are the electrical contractor personnel that are involved in the material procurement process.

Figure 3 illustrates the way in which the application works. The user will select a module from the Main Menu screen of the application. The main menu is comprised of six different command buttons, which represent the modules in Level 2. The General Info command button brings up general information about the company. The Help command button brings a screen that offers some help on how to use the application and some contact information in case that there are problems with the application. The About command button opens a window with information about the developed application. The two main modules in this application are the database module and procurement module.
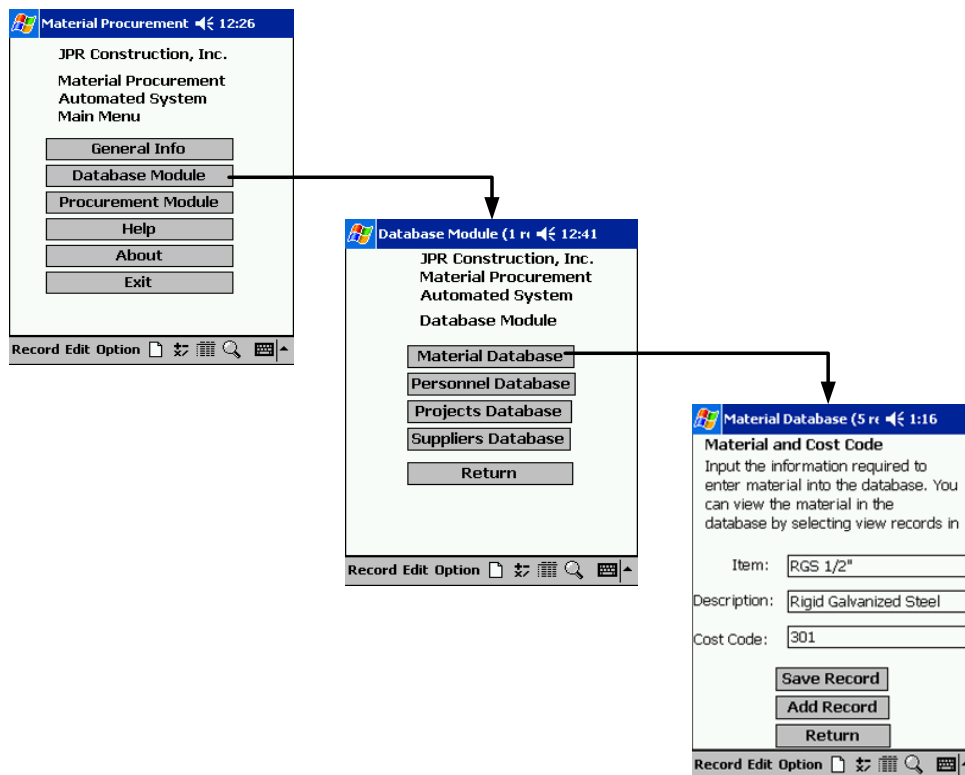

Figure 3. Application Tree on the Pocket PC.

Figure 3 illustrates the application tree of the application, using Pocket PC screenshots, if the user wants to access the Material Database. In the Main Menu, the user selects Database Module, in the database Module the user selects Material Database, then the Material Database screen will appear. This module allows the user to add, delete, view or edit information about any type of material used by the company.

The Procurement Module is one of the important modules of the application and it is comprised by four main sub modules: Stock Requisition, Problem Sheet, Material Releases and Receiving Report. These four databases mimic the paper based forms that are used in the material procurement process. The first step in the automation effort was to develop an electronic representation of the paper forms currently used by the company.

Figure 4 depicts an electronic version of the Stock Requisition. Figure 4 illustrates an electronic version of the top part of the Stock Requisition form. The data fields illustrated in the figure correspond to the data fields of the Stock Requisition form which include general information about the project such as the project's name, project location, project number, foreman's name and the name and phone number of the contact person. All this information is obtained from the databases that are contained in the Database Module.

Figure 4. Electronic Stock Requisition Form.

Figure 5 depicts an electronic version of the bottom part of the Stock Requisition form. The data fields in this form correspond to the information about material item, description and cost code in the Stock Requisition form. In our application, information about material item, description and cost code is obtained from the Material Database. The foreman inputs information about the quantities and date when the material is required. Once completed, this form is sent electronically to the PM.

Figure 5. Electronic Stock Requisition Form.

Similarly, an electronic version of all the forms used in the material procurement process was created in the Pocket PC. The linkage between forms was established for information sharing purposes to facilitate the process of filling the forms and minimize the manual input to the user. Figures 6 and 7 illustrate the electronic version of the Material Release form and the Problem Sheet.

Figure 6. Electronic version of the Material Release Form.

Figure 7. Electronic version of the Problem Sheet.

Conclusion

Paper based data collection in the field has been used in the construction industry for a long period of time. The use of paper based forms will continue until the construction personnel realize the benefits of automating the field data collection process. One of the advantages of automated field data collection over manual data collection includes the elimination of double entry of records, which minimizes errors while re-entering data for record generating purposes. Other benefits include the reduction of paperwork, automatic generation of reports, faster data distribution due to automatic generation of reports, and increase in efficiency in the overall process, which translate into cost savings due to reduction of labor time.

The compact size of Pocket PCs allows them to be easily carried to the construction site and with the ability to connect to the Internet, all project data can be accessed and updated easily. Bryant and Pitre state that some advantages of Pocket PCs include:
- Pocket PCs are extremely portable and could be carried anywhere relatively easily when compared to laptops
- Pocket PCs are very flexible and allow any kind of application to be programmed and run in their operating system
- Pocket PCs can be easily used by any person, and does not required expertise knowledge with computers
- Pocket PCs allow rapid transfer of the data collected to a corporate database

When implementing any new technology there are always challenges that need to be addressed. For the implementation of Pocket PCs for automating the data collection process, there some challenges that need to be tackled. There are some issues related to usability and personal issues. One issue is just facing the challenge itself. Another issue to consider when implementing change is management buyout and support. Other issues deal with the time needed to learn the new tools and systems implemented could be of concern for the top executives and that field personnel are more resistant to change than top executives.

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