CONSTRUCTION BUSINESS PROCESS AUTOMATION USING WORKFLOW TECHNOLOGY

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ABSTRACT : This paper presents the core technology of Construction Business Process Automation to model and automate construction business processes. Business Process Reengineering (BPR) and Automation (BPA) have been recognized as one of the important aspects in construction business management. However, BPR requires a lot of efforts to identify, document, implement, execute, maintain, and keep track thousands of business processes to deliver a project. Moreover, existing BPA technologies used in existing Enterprise Resource Planning (ERP) systems do not lend themselves to effective scalability for construction business process management. Application of Workflow and Object Technologies would be quite effective in implementing a scalable enterprise application for construction community. This paper present the technologies and methodologies for automating construction business processes by addressing how: 1) Automated construction management tasks are developed as software components, 2) The process modeling is facilitated by dragging-and-dropping task components in a network, 3) Raising business requests and instantiating corresponding process instances are delivered, and 4) Business process instances are executed by using workflow technology based on real-time simulation engine. This paper presents how the construction business process automation is achieved by using equipment reservation and cancellation processes simplified intentionally.

Key words : Information System, Office Automation, Workflow Technology, Business Process Reengineering (BPR), Business Process Automation (BPA)

1. INTRODUCTION

The construction industry has experienced remarkable productivity improvement due to the advancement in Information Technology (IT) (Li. et al., 2000). It has affected the construction business in many ways by reducing operating costs at the organizational level, and improving communications among project participants through networking and information sharing (Oxman 1995), etc. Integrated databases, database query and analysis, and networking have dramatically improved the efficiency and capacity for processing information. These benefits have been translated into productivity and quality improvement in the construction industry.

IT based Information Systems (IS) facilitate the redesign of organizational functions and management processes to achieve better coordination between design and constrution through improved data accessibility and common systems that are designed to process data (Ahmad et al., 1995). A traditional view of IS as tailor-made and an integrated database application is evolving. IS today is used for supporting interactions between a large variety of inde-endent, multi-vender data sources and legacy applications that may run on heterogeneous platforms and distributed information networks. New advanced IT tools are emerging for improving enterprise-wide communication (Aalst and

Hee 2002, Liu, et al., 2003). In construction domain, it is recognized that integrated enterprise applications (e.g., Enterprise Resource Planning Systems) would lead to productivity improvement in construction by enabling timely information sharing (Shi and Halpin; 2003). It has been recognized that the key of an ERP system is to automate business processes.

Each construction company has thousands of processes representing its own business practices for delivering its service and constructed facilities. Executing those instances requires complex interactions between project participants at different levels of the organizational hierarchy. Depeding on the procedures implemented in the organization, the activities involving in a process model may be deployed in different ways. Nevertheless, every construction firm is expected to identify, document, implement, and maintain its' business processes, to ensure that those processes are in place in a systematical manner (4.1 element, ISO 9001; 1996, ISO 9000-1; 1994; ISO 9000-2; 1993, Hoyle, D; 1998), to manage the configuraions of the processes, and to ensure an effective implementation of the processes (4.2 element, ISO 9001; 1996). Furthermore, a continuous demand for improved performance from either external (e.g., revision of requirements and/or standards) or internal sources (e.g., reorganization of management structures) requires flexible Business Process Automation (BPA) technologies.

2. WORKFLOW TECHNOLOGY IN THE CONSTRUCTION INDUSTRY

The construction industry is commonly regarded as highly fragmented. Delivering a construction project requires the involvement of many independent parties such as project owner, contractor, architect, designer, enginering consultant, sub-contractors, suppliers, and manufacturers, etc. The interactions among those participants are usually not predictable and the complexity between their relationhips depends on the selected project delivery system.

Many construction firms have been experiencing poor coordination/communication among project participants. In order to improve performance, many firms have documented, implemented, and maintained their business processes. However, the added paper work has caused overburdens from tracking the status of process instances, recording process data, documenting and managing configuration of business system as process models change over time, and taking corrective and preventative actions on procedural nonconformities.

Every construction firm has thousands of processes to deliver its services and constructed facilities. Delivering a project into a constructed facility requires identifying, documenting, implementing, and executing those processes. Internal or external demands require those processes in place and to be continuously reengineered to best suite business needs (ISO 9001; 1996, Hoyle, D; 1998). BPR in construction also decomposes business systems into processes and intends to achieve information sharing in a virtual enterprise setting (Hassan and McCaffer; 2002).

The construction industry has been constantly re-engineering its business processes. The effort has resulted in the necessities including: (1) modifying existing applications, (2) writing new applications, (3) changing system architecture, and (4) delivering an integrated enterprise application in a distributed and heterogeneous environment over the Internet. BPA has become an important topic in many construction firms (Brown and Riley; 2000) and IT has been recognized as a tool to achieve better coordination between organizational functions and processes in the construction industry (Ahmad et al; 1995). The construction community has also recognized that a web-based 3-tier Client/Server architecture can best suite the need for Computer Supported Cooperative Works (CSCW) in a construction enterprise setting. Shi and Halpin (2003) proposed CERP that is integrated enterprise applications architecture based on 3-tier Client/Server for construction ERP system in recent year. The expected benefits include improved coordination among project participants through networking and information sharing (Moselhi, et al., 2004; Citadon http://www.itadon.com; Primavera Expedition www. rimaver.com).

WfMS plays an important role to separate flow logic in an ERP system from its function logic. Because WT can ha ndle flow logic and function logic separately, it is believed that WfMS can function as a generic tool for int egrating different types of data, applications and people in a wide range of domain including the construction industry. WfMS is a promising IT domain for automating business processes.

The construction business may take an advantage of the advancement in BPR, BPA, and Workflow Technology (WT). If a construction firm can synchronize its information such as availability of resources of the company and need for resources in on-going projects by using ERP, the company may find a better way to utilize its internal and external resources.

3. SYSTEM METHODOLOGY

The Construction Business Automation System (CBAS) developed is used as a working platform for a seamless integration between desktop processing at construction project sites, departments, headquarters, and other parties involved in a project over the Internet (Lee 2005). Due to a diversity of processes and transactions involved in construction business, construction firms can expect remarkable benefits from automating their business processes by using the developed technologies in this research. As a construction project gets more complicated and the number of processes explodes, it will make the task of managing the project more manageable. Business Process Automation (BPA) in construction may lead to the improvement of productivity and quality in construction projects. It may also enhance the competitiveness of a company against its competitors.

3.1 Modeling business processes using task components

Appropriate task components are used as the basic building blocks to create a model for the process. A task component can be placed in any process model with the same function. A number of task components must be developed in order to model various business processes. The entire developed task components for process modeling are available in the task library. The components in the library provide the basic building blocks for constructing process models.

3.2 An example process model

An example process model, called *Equipment_Reservation_Cancellation,* is created in Figure 1, which provides the business logic for canceling a reservation of a piece of equipment.

There are four tasks in the model. The first node stands for the start point of the process. It identifies the start of th e process. Every process should have a Start Node. It becomes necessary when there are parallel sub-paths at the beginning. For the similar reason, an "Exit" node is used for merging parallel paths to one single end. It identifies th e end of the process. The tasks in the model are detailed in Table 1.

Task "Delete" deletes a reservation record from the reservation table in the Equipment database. A log record is then inserted into the Log table for tracking the activity by using the "Write_Log()" task component. After that, the result is displayed on the requester's monitor by using "Display_message()". Finally, a confirmation message is

sent to the equipment department. The logic sequence between every two tasks is described by an arrow as shown in Figure. 1.
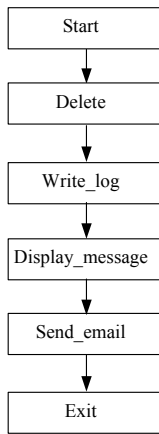

Figure 1. The Equipment_Reservation_Cancellation Process

3.3 Raising a request

A request is the starting point of a business process. Background information should be provided in the request. Raising a management request is served with a custom-request form. A request is associated with at least one process model. A number of request forms are designed and organized in the Request Navigator (RN) so that users can easily find their needed forms to raise their requests. .A request form is used to enter data attribute values to process variables to be used by relevant task components at runtime. An example request form is shown in Figure 2. The form "Equipment Cancellation Request Form" may be used for to cancel the reservation of a piece of equipment. It contains the following user defined process attributes (e.g., Project_ID, Request_by, Equipment_Code, Cancellation_ Date, Reservation_ID, etc).

The request information can be captured in the syntax: CancelFrm [(`Equipment_Reservation_Cancel_Request_`), (Project_ID = `CE03231`), (Request_by = `PM001`) (Equipment_Code = `BackHoe`), (Cancellation_Date = `12/23/2003`), (Reservation_ID = `CAEPR001`)];

3.4 Instantiating an instance of a process model

After a request is officially raised, an instance of the selected process model will be instantiated. The instance representing the business process will be added to the pool of the active processes in the workflow engine. Process-level variables are retrieved their values from the request form.
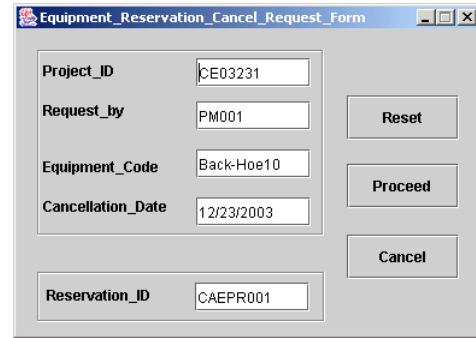

Figure 2. The Equipment Cancellation Request Form

3.5 The Internal Working Mechanism

Figure 3 shows an example of defining the "Delete" task component at design time. After the task is executed with the ProcessDataSet as process level variables, a standard SQL (e.g., deleteSQL) as a String ADT will be created to set the Data Source Name (DSN) and delete a record as shown in Figure 4. The design time and run time mapping is accomplished using the JavaScript adapter. The adapter bridges the interactions between Workflow Engine and the task component.

Table 1. Detailing Task Components in the Equipment Reservation Cancellation Process

| Task ID	Task	What	WhatElse	Action
1	Start	CancelFrm [(`Existing_Reservation_Cancel_Request_`), (ProjectID = `a`"), (Request_by = `b`), (Equipment_Code = `c`), (Cancellation_Date = `d`), (Reservation_ID = `e`)];	-	Auto
2	Delete	(Reservation_ID = `Reservation ID`) AND (ProjectID = `Project_ID`)	DSN=(C:\…\SearchDBServer\Equipment.mdb), Database=Equipment, Table=Reservation	Auto
3	Write_log	(ProjectID = Project_ID, PMID = Request_by, TimeStamp = Cancellation_Date)	DSN=(C:\AAA\SchDB\SearchDBServer\Equipment.mdb), Database=Equipment, Table=WriteLog	Auto
4	Display_msg	(Equipment/Equipments is(are) successfully discharged.) , (Reservation_ID, Equipment_Code, Cancellation_Date, Project_ID)	Request by	Semi
5	Send_emil	(Equipment/Equipments is(are) successfully discharged.), (Reservation_ID, Equipment_Code, Cancellation_Date, Project_ID)	Equipment Department	Auto
6	Exit	-	-	Auto

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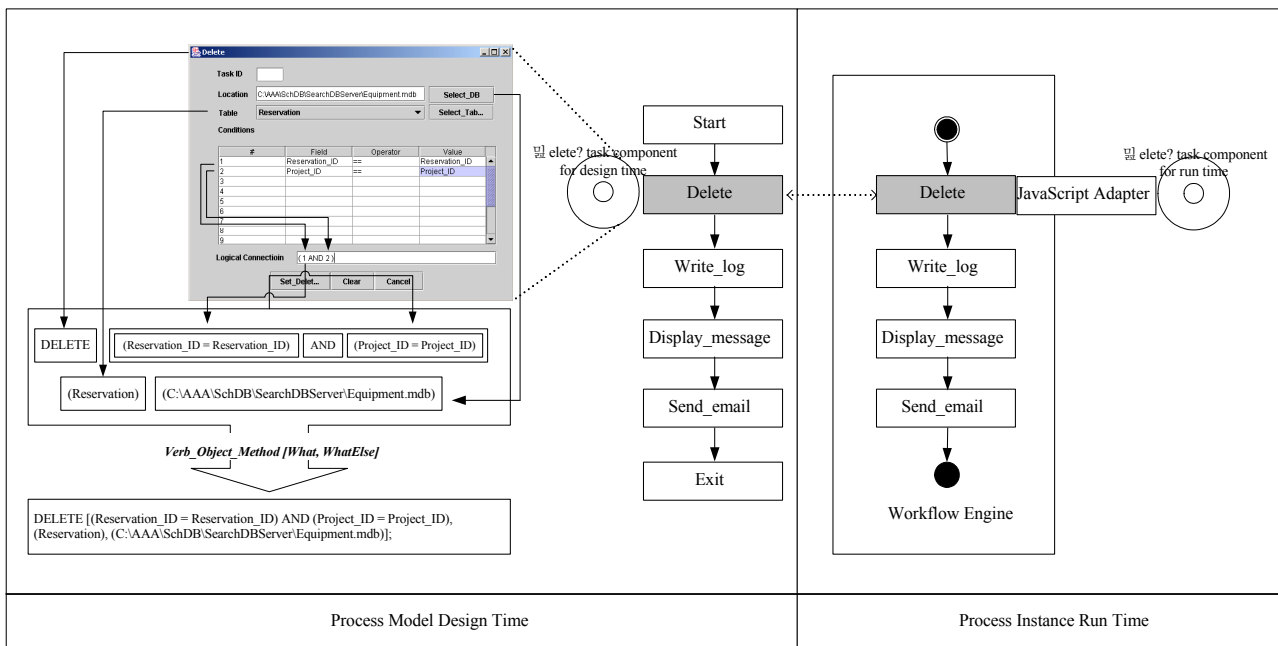
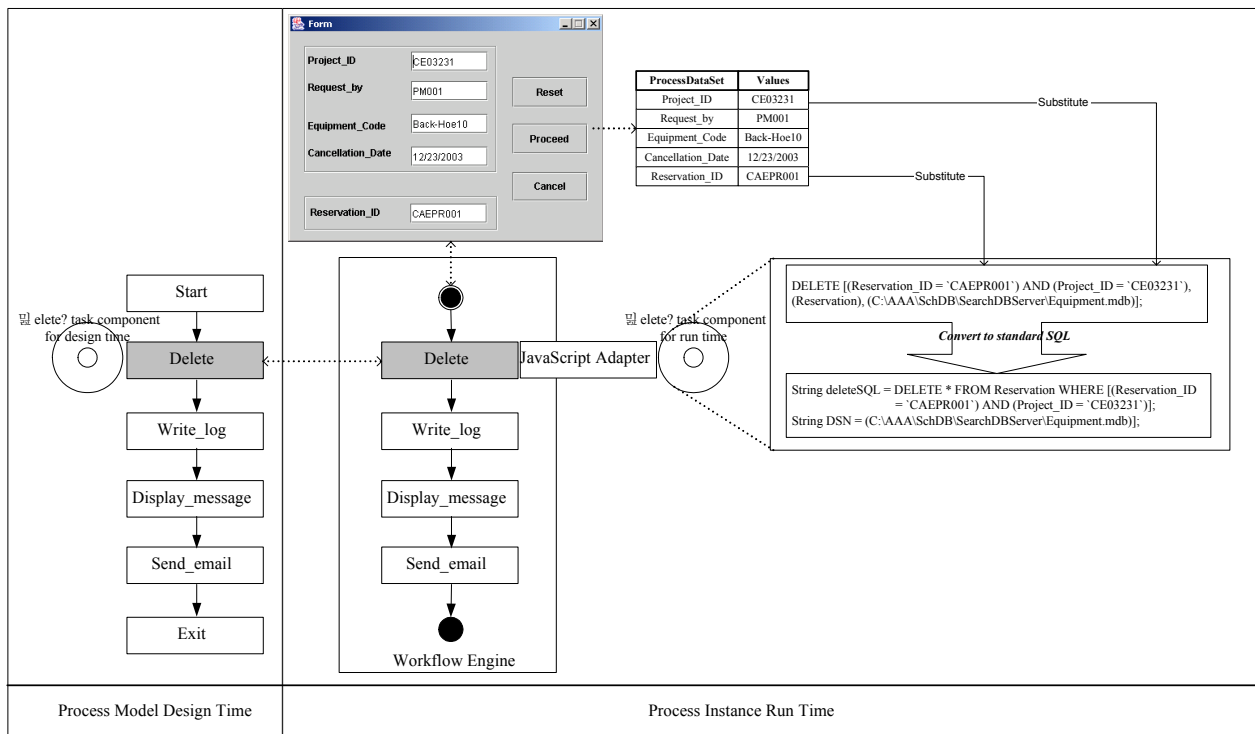**Figure 3.** Defining "Delete" Task Component at Design Time

Figure 4. Mapping "Delete" Task Component between design time and Run Time

The task component at design time (Figure 8.2) produces a statement as: DELETE [(Reservation_ID = Reservation_ID) AND (Project_ID = Project_ID), (Reservation), (C:\…\SearchDBServer\Equipment.mdb)]. At run time (Figure 8.3), the variables are substituted with actual values as: DELETE [(Reservation_ID = `CAEPR001`) AND (Project_ID = `CE03231`), (Reservation), (C:\…\SearchDBServer\Equipment.mdb)]. Internally, the task component creates two arguments. The one is a String type SQL statement (e.g., DELETE * FROM Reservation WHERE [(Reservation_ID = `CAEPR001`) AND (Project_ID = `CE03231`)];). The other is a String type DSN (e.g., (C:\…\SearchDBServer\Equipment.mdb);).

4. CASE STUDY: EQUIPMENT MANAGEMENT WORKFLOW

This section presents automated equipment manage-

ment workflow using reservation cancellation process. A construction enterprise may achieve a higher level of equipment utilization with the support of an automated workflow that provides real-time planning, scheduling, and allocating equipment in a timely fashion.

Due to changed conditions on a job site, to cancel a previous reservation is a typical process in project management. This section uses this example to illustrate the developed technologies. A reservation cancellation process, "Equipment Reservation Cancellation", is developed for canceling an existing reservation.

4.1 Modeling the Reservation Cancellation Process

The Reservation Cancellation process model is created with four task components (e.g., Delete, Write_log, Display_message, and Send_email) as shown in Figure 5.

By using Interface 1 (IF 1) of the Workflow Reference Model, the process model is exported to the selected WfMS (i-Flow). After the created process model is imported to the WfMS, it is saved in the process model repository as shown in Figure 6.
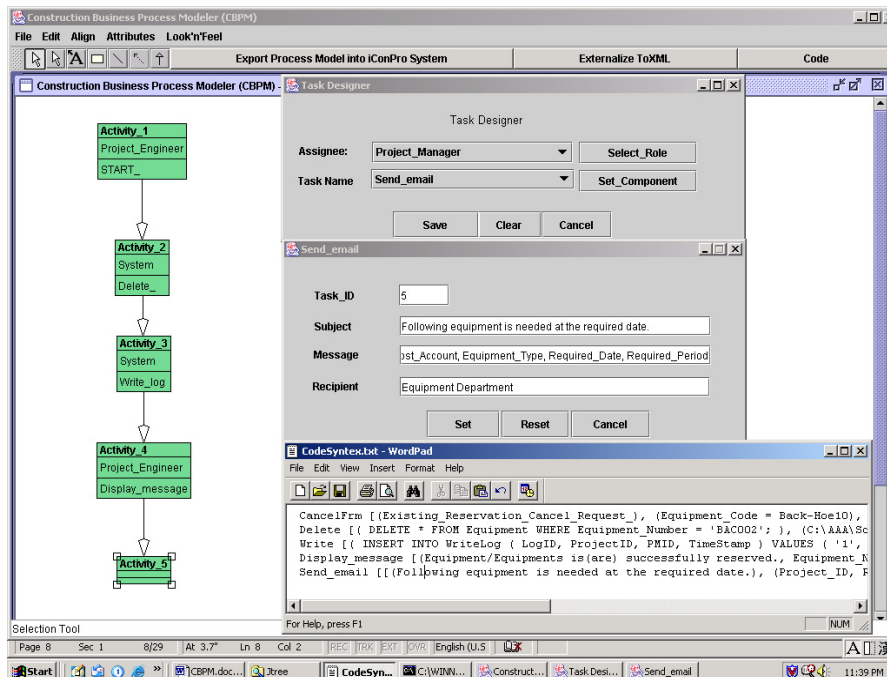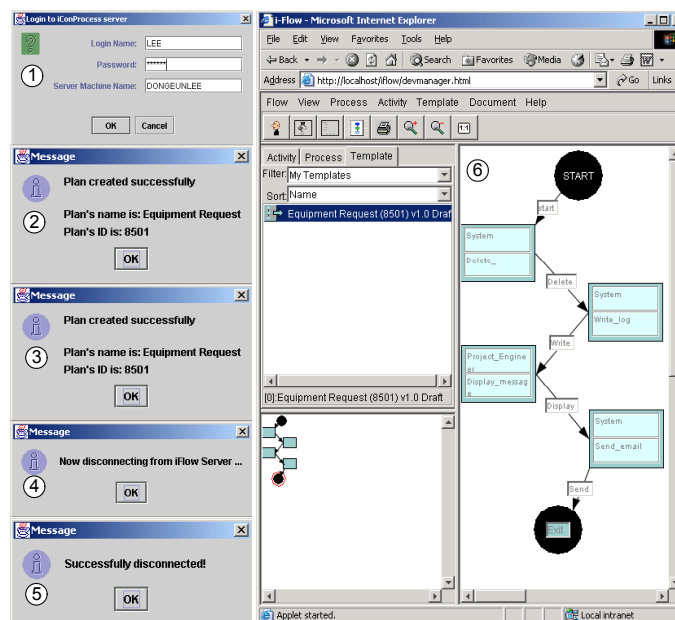

Figure 5. Modeling Equipment Reservation Cancellation Process by using CBPM

Importing Process   After Importing the Process Model

Figure. 6. An Imported Process Model in WfMS

4.2 Modeling the Reservation Cancellation Process

When a previous reservation needs to be cancelled, a user (e.g., project engineer) starts the process with filling out request form. A correct request form can be identified by using the request form navigator (RN). After a correct form is selected, RN instantiates an instance for the "Equipment Reservation Cancellation Request Form" as shown in Figure 2. It shows that "Backhoe-10" will be canceled from the previous reservation for project "CE03231" with the detailed information for the cancellation such as which project, by whom, which equipment, when, etc.

By incorporating the attributes and variables in the request form, a request can be fully defined. The request data object are captured as described earlier. After the user click the "Proceed" button in Figure 2, the request will be sent to the intelligent management server (WfMS) at 2nd-tier, which will process the request as a data set, identify an appropriate process model, and instantiate an instance for the model.

4.3 Executing the Reservation Cancellation Process

A process instance is instantiated and the task components are executed in the sequence as defined in the process model.

- **Executing the "Delete" component:** When the first task (i.e., "Delete") in the process model is executed by the workflow Engine, a previous reservation will be searched on the equipment reservation database.

- **Executing the "Write_log" Component:** Executing the second task "Write_log" in the process model will insert a record in the log table in the database for tracking purpose.

- **Executing the "Display_message" Component:** The next task "Display_message" will display a message on the client side computer to inform the user that the cancellation has been successfully performed.

- **Executing the "Send_email" Component:** Finally, "Send_email" task will send a confirmation e-mail to the equipment department as shown in Figure 7.
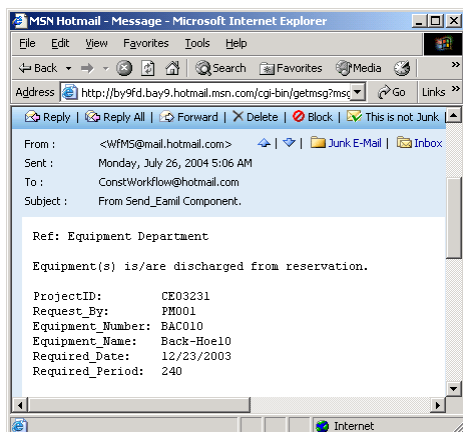

Figure 7. Sending a confirmation e-mail

The previous examples show that business process like reserving or canceling a reservation can be automated by using workflow technology. Project personnel can participate in a business process at any time from anywhere through the technology.

5. CONCLUSION

The usage of Workflow Technology provide a working platform for a seamless integration between desktop processing at construction project sites, departments, headquarters, and other parties involved in a project over the Internet. It improves management efficiency and information sharing. The business process modeling technology with atomic reusable task components and process automation simplify BPA for construction. The adaptation of the capability of Workflow Technology (WT) and Object Technology (OT) enable business process modeling and automation without requiring much WT professionals' involvement. Construction firms are expected to achieve remarkable benefits from automating their business processes by using the developed technologies in this research. As a construction project gets more complicated and the number of processes explodes, the research finding and development will make the task of managing the project more manageable. Business Process Automation (BPA) in construction may lead to the improvement of productivity and quality in construction projects. It may also enhance the competitiveness of a company against its competitors.

REFERENCES

[1] Ahmad, I. U., Russel, J.S., and Abou-Zeid, A. (1995). "Information technology (IT) and integration in the construction industry" *Const. Mangt &Economics*., 13(2). 163-71.

[2] Hassan, M. Tarek and McCaffer, Ron., (2002) "Vision of the large scale engineering construction industry in Europe", Automation in Construction 11(4). 421-437.

[3] Hoyle. David., (1998) *ISO 9000 Quality Systems Handbook*. 3rd ed. Utterworth Einemann. Ltd.

[4] Dong-Eun, Lee and Jonathan, Shi, (2005). "A Construction Business Automation System." *Construction Research Congress*. ASCE. San Diego, CA. 654-658.

[5] Liu, David., Cheng, Jinxing., Law, H. Kincho., Wiederhold, Gio., and Sriram, D. Ram. (2003). "Engineering Information Service Infrastructure for Ubiquitous Computing." *J of Computing in Civil Engrg*., 17(4), 219-229.

[6] Moselhi, Osama., Li, Ji., and Alkass, Sabah. (2004) "Web-based integrated project control system" *Const. Mangt &Economics*, 22(1), 35-47.

[7] Oxman, Rivka., (1995) "Data, knowledge and experience in multiuser information systems**."** *Const. Mangt &Economics* 13(5). 401-410.

[8] Shi, Jonathan and Halpin, W. Daniel. (2003). "Enterprise Resource Panning for Construction Business Management". *J. Constr. Eng. Mgnt*., 129(2), 214-221.