# USING BUSINESS PROCESS MANAGEMENT IN DESIGN COORDINATION FOR CONSTRUCTION PROJECTS

Mohamed Marzouk, Associate Professor, mm_marzouk@yahoo.com
Ahmed Al-Desouky, Graduate Student, ouee_desouky@yahoo.com
Moheeb El-Said, Professor of Construction Engineering and Management, elsaid1204@yahoo.com
*Structural Engineering Department, Faculty of Engineering, Cairo University, Egypt*

## ABSTRACT

The design process of building projects and properly managing the changes are the main key aspects to control projects and ensure a consistent and well-coordinated design. This research presented an information model to store design information, record design rationale, and manage design changes. The proposed model incorporates a central building components library (BCL) that is used to create a complete building project hierarchy (BPH). This paper presents a business process management model to aid in design coordination in engineering consultancy firms. The model provides practical recommendations and guidelines to avoid lack of coordination on design process. A detailed case study is presented to demonstrate the practical use of the proposed business process tool.

**Keywords:** Business process management, Engineering consultancy firms, Building project hierarchy

## 1. INTRODUCTION

Engineering management plays a very important role in the economics of most developing countries. Nowadays, management is very common to all projects, while each design project has additional and unique set of design tasks. Project design failure occurs when a party (or parties) of the project team is/are unable to perform his/their contractual duties in presence of the project lack of coordination . In many cases, execution of management plan is an ideal tool in spite of awaiting the occurrence of problems facing the project and then try to react in order to avoid failure. Business project management has been proposed as a solution to provide insight into potential problem areas and to identify, address and eliminate them before derailing the project. The business process management interference in design life cycle of a project is not to avoid all cases of lack of coordination and client requirements implementation (which are impossible) but to reorganize and manage them.

A Business Process Management is "a collection of related, structured activities that produce a service or product that meet the needs of a client" (Wikipedia 2010). These processes are critical to any organization as they generate revenue and often represent a significant proportion of costs. As a managerial approach, (BPM) considers processes to be strategic assets of an organization that must be understood, managed, and improved to deliver value added products and services to clients (Smart et al. 2008). This foundation is very similar to other Total Quality Management or Continuous Improvement Process methodologies or approaches. Business Process Management goes a step further by stating that this approach can be supported, or enabled, through technology to ensure the viability of the managerial approach in times of stress and change. In fact, BPM is an approach to integrate a "change capability" to an organization both human and technological (NIH 2007). As such, many BPM articles and pundits often discuss Business Process Management from one of two viewpoints: people and/or technology. Business Process Management tools now allow the user to (Wikipedia 2010):

- Design: The process or the process improvement.
- Measure: Simulate the change to the process.
- Analyze: Compare the various simulations to determine an optimal improvement.

- Improve: Select and implement the improvement.
- Control: Deploy this implementation and by use of user defined dashboards to monitor the improvement in real time and feed the performance information back into the simulation model in preparation for the next improvement iteration.

The objectives of this research are: i) identify the main departments and their tasks, which may affect the project design life cycle generally for buildings and consequently the success or failure of the project coordination, ii) indicate the relative importance of every stage, iii) gather the activities affecting project management, iv) establishing a computer program in order to assist in project coordination, and v) develop practical recommendations and guidelines to avoid or decrease the effect of lack of coordination in design process. A detailed case study is presented to demonstrate the practical use of the proposed business process tool.

## 2. BUSINESS PROCESS MANAGEMENT APPLICATION IN DESIGN PROCESS

Poorly communicated design changes lead to modifications that are costly and difficult to manage. With the dynamic nature of the design process and the fact of frequently introduced changes, manual practices lead to inefficiencies in the design that affect the overall quality of the construction (Dubois and Parand 1993). As a managerial approach, Business Process Management (BPM) considers processes to be strategic assets of an organization that must be understood, managed, and improved to deliver value added products and services to clients (Smart et al. 2008). This foundation is very similar to other Total Quality Management or Continuous Improvement Process methodologies or approaches. A primary reason for these problems is the lack of a unified computer based model for organizing design information and storing its rationale (Hegazy et al. 2001). Present computer technologies, such as electronic mail and the Internet allow for the electronic exchange of information and can substantially increase the amount and variety of project information communicated as compared to traditional manual methods. Electronic media cannot only convey geometric information such as drawings, but can also transfer text information such as specifications, bills of quantities, and design rationale statements. Tools such as groupware videoconferencing, remote access, file sharing, and whiteboard discussions can be used, individually or combined, to provide custom solutions for design coordination and site to office communication . Currently, some examples exist of systems developed to allow the access and sharing of project progress information by participants in remote locations (Seesing 1996).

In addition to the information presented earlier, survey respondents provided several interesting comments and criticisms to current practice that can give insight into future research directions. One of the important issues raised is the problem associated with the large amount of paper work involved in the design process. Some of the disadvantages of using paper as the main communication media have been outlined earlier by Teicholz and Fischer (1994). A major obstacle to the efficient use of electronic files for communicating design information, despite the advances, is the lack of appropriate filing systems for organizing the multitude of drawing files with their several updates and other related documents concerning specifications, changes, and other information. In addition to security problems , confidentiality, and acceptability as an official medium. A business process can be decomposed into several sub processes, which have their own attributes, but also contribute to achieving the goal of the super process. The analysis of business processes typically includes the mapping of processes and sub processes down to activity level. A business process model is a model of one or more business processes, and defines the ways in which operations are carried out to accomplish the intended objectives of an organization. Such a model remains an abstraction and depends on the intended use of the model (Dufresne and Martin 2003). It describes the workflow or the integration between business processes. It can be constructed in multiple levels.

Usually a business model is created after conducting an interview, which is part of the business analysis process. The interview consists of a facilitator asking a series of questions to extract information about the subject business process. The interviewer is referred to as a facilitator to emphasize that it is the participants, not the facilitator, who provide the business process information. Although the facilitator should have some knowledge of the subject business process, but this is not as important as interviewing business experts. The method is important because for most enterprises a team of facilitators is needed to collect information across the enterprise, and the findings of all the interviewers must be compiled and integrated once completed (Dufresne and Martin2003). The business analysts can determine if the existing business processes and information systems are sound and only need minor modifications, or if reengineering is required to correct problems or improve efficiency. Consequently, business process modeling and subsequent analysis can be used to fundamentally reshape the way an enterprise conducts its operations (Osterwalder 2004). More advanced forms such as human interaction management are in the complex interaction between human workers in performing a workgroup task. In this case, many people and systems interact in structured and sometimes completely dynamic ways to complete one too many transactions (NTAID 2008). A variety of Internet based software and hardware systems are being produced at an astonishingly fast pace. These systems cover a wide range of tools for individuals, small businesses, and large enterprises who can tie their local or wide area networks to the internet, forming intranets. With little cost involved, tools such as Internet telephones, video conferencing, remote control, Internet meeting, white board discussions, and document conferencing may be used, individually or combined, to provide custom solutions for design coordination and site to head office communication as well. In addition to remote communication, internet abilities to trace and document users' actions have direct application in the management of the many anticipated changes during design. Using the proper tools, a network administrator can monitor users' access times, the commands they use, and the changes they make.

## 2.1 Proposed planning cycle

A communications plan describes the information to be disseminated to all project parties to keep them regularly informed of the progress of the project. A clear communications plan is vital to the success of the project, as it helps to ensure that all project resources and parties who are working towards the same project objectives, and that any problems are to be overcame in a planned and informed manner. The communications plan contains the following information:

- The information requirements of each project party;
- A schedule of the communication events, methods and release dates;
- A matrix highlighting the resource involved in each communication event;
- A clear process for undertaking each communication event within the project.

List any assumptions made during the communications planning process. For example, it might be assumed that:

- Communications tools will be provided as required;
- Adequate communications resources will be available when needed;
- Communicating staff have the required expertise.

While the project team are physically producing each deliverable, the project manager implements a series of management processes to monitor and control the activities being undertaken by the project team, where change management is the process by which changes to the project scope, deliverables, timescales or resources are formally requested, evaluated and approved prior to implementation. A core aspect of the project manager's role is to manage change within the project. This is achieved by understanding the business and system drivers requiring the change, identifying the costs and benefits of adopting the change, and formulating a plan for implementing the change. After the communications plan has been agreed, the communications management process is invoked to ensure that all communication events are undertaken in a clear and coordinated manner. The cycle starts from the client considering the external and internal governmental forces that might face the project. At this point, the client stage ends and the consultant stage will begin as shown in Figure 1.

The management team should evaluate the project and the expected factors that could lead to project success and to take that decision whether to proceed in the project or not. In case of rejecting the project, the business department should sends a notice to the client otherwise. In case of project acceptance, the proposal manager starts to initiate and prepare the proposal, taking into consideration the data that will be taken from the client and reviewing the terms of reference. Also, s/he visits the site to be familiar with the location conditions, after that the proposal manager prepares drawing list and identify the required manpower then starts preparing the proposal documents for review.

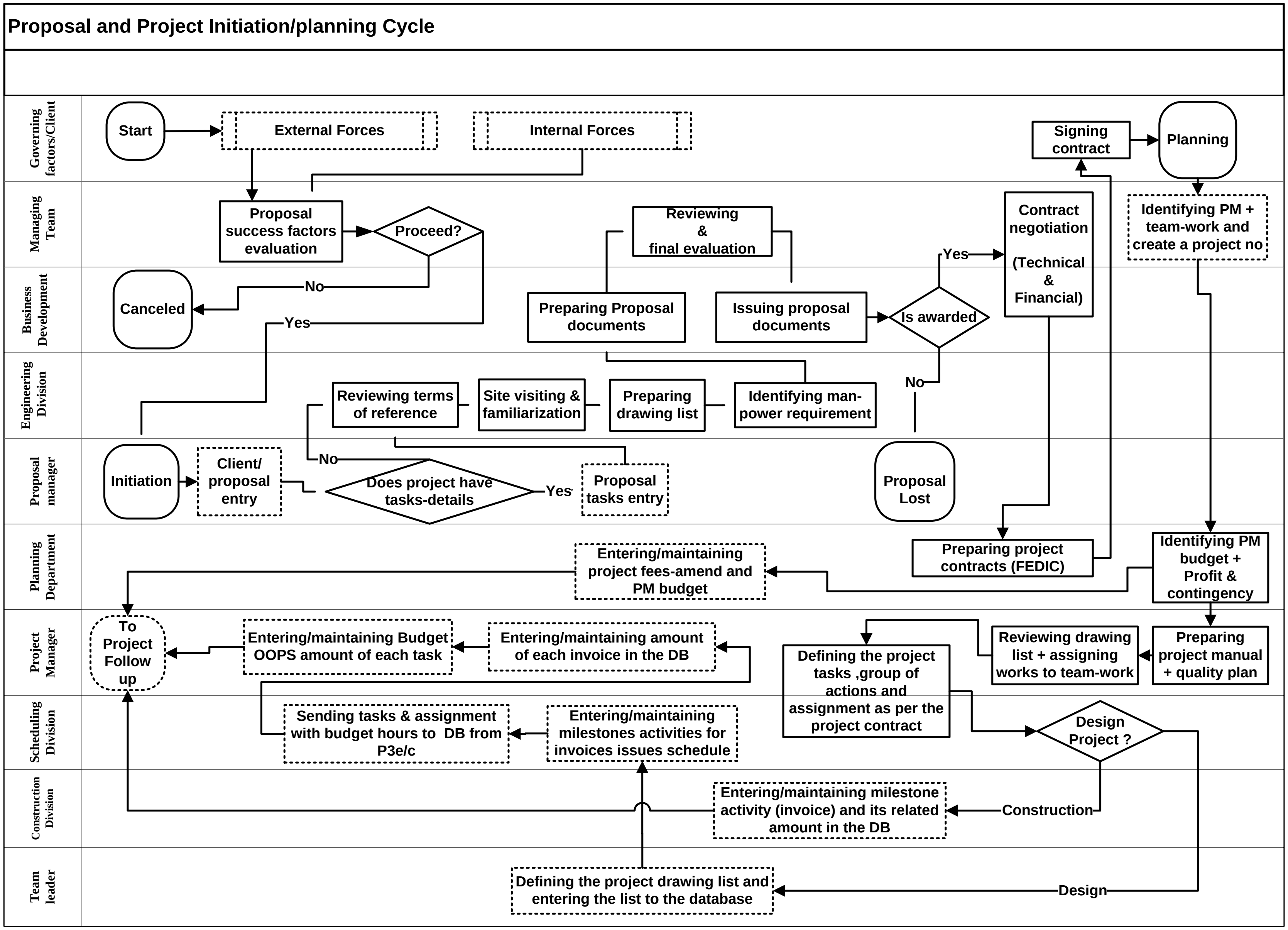


Figure 1: Flowchart of departments’ tasks in engineering consultancy firms

Evaluation of the proposal is carried out to reach the final stage of issuing the proposal documents. If the project is awarded, then a contract negotiation takes place for both (technical and financial aspects) according to FEDIC conditions. After all the parties agree on the final draft of the contract, two original copies are signed from both parties. Then, a project manager is identified along with the team members and an ID is assigned to the project. At this stage, the project manger act, as administrator in which s/he receives the project budget hours from scheduling department to control the hours that will be spent by the team leader. Aided by the total budget and the time schedule, the project manger initiates the project manual and quality plan, and reviews the drawing list and assigns works to the team. Then, the project manger starts to define the project tasks group of actions and assignments as per the contract scope of work. Through the design life of the project, the project manager should monitor, control and track all the disciplines as to get at the end a full design package to be delivered to the client as all the deliveries are linked to the invoices. Note that many of the available methods are so common without mentioning them to be influencing coordination . No matter what one calls the following methods coordination or control, they are important to the success of any organization.

## 2.2 Building project hierarchy

For proper multi-user access and modification rights, therefore, it must be established for the unified Building Project Hierarchy (BPH) to suit all parties as shown in Figure 2. Another difficulty comes from the fact that the work of each discipline will be scattered in the BPH model. Therefore, a suitable database design, a proper interface, and powerful reporting are necessary to be sure that the unified BPH representation is successful and that encapsulates all multidisciplinary design information into the building components with no redundancy and, as such promotes coordination and improves the quality of design. Beside the above mentioned techniques , the proposed BPH allows designers in all disciplines to instantly view the components of all other disciplines in the same hierarchy. As mentioned before, three stages are used in the proposed building project hierarchy:

- Project Level: a single object with attributes that describe the site, project size, setbacks, etc.
- Building Level: can include more than one stage with attributes that include the overall tasks for each stage.
- Discipline Level: includes the different tasks for each discipline.

Level encompasses four main objects corresponding to the architectural, structural, mechanical and electrical systems within the stage. The stage includes objects for the detailed building and the associated attributes component. For example, material, code restrictions, and type of soil are attributes of a project. The proposed building project hierarchy provides a unique description for each component in a building project.

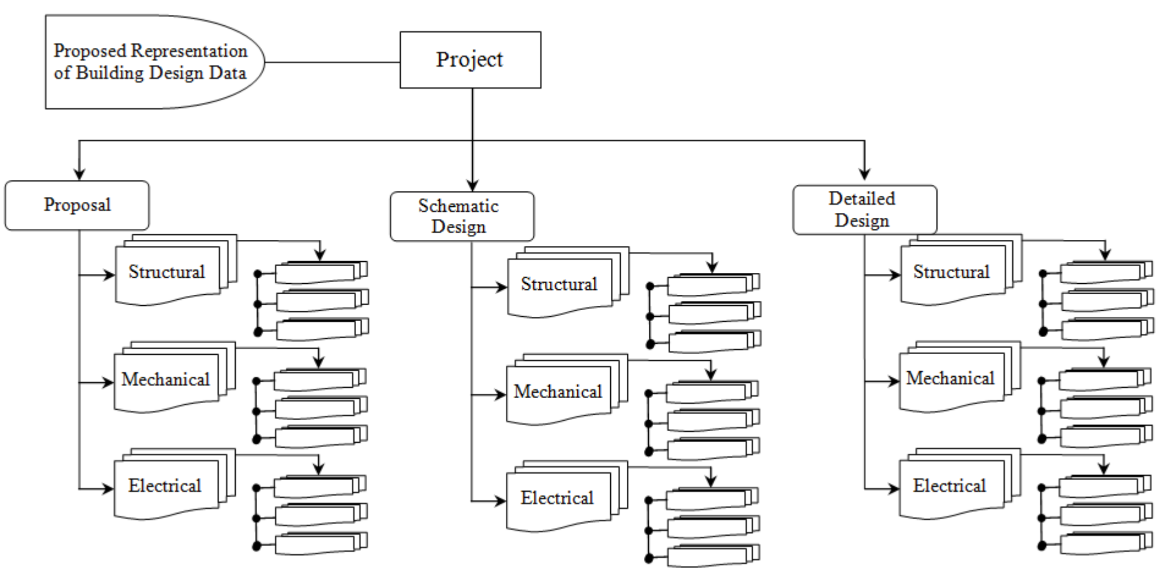


Figure 2: Unified building project hierarchy model

## 2.3 Coordination among Multidisciplinary Design Teams

A survey was made to collect data for the main common activities of all the departments for the various stages. This Survey based on Selecting and interviewing twelve experts in all the disciplines as each one is specialist in his field such as civil, mechanical, electric, architectural, etc. The aim was to build general library, this library will be the origin for building the project hierarchy which reflect the project framework through the design different phases. The experts have identified almost three hundred fifty activities for each discipline. These activities are distributed on twelve disciplines over three main stages, and are selected and distributed on the disciplines and stages not on the spaces program. Data collection elicited the participants' practice in coordinating a design among the different disciplines working on a project. Also, it elicited some of the multi team coordination problems frequently encountered and designers' used to ensure consistency and proper exchange of information among teams. A lot of information was provided by Respondents regarding their methods of:

- Distributing project information
- Administering design changes, as two important aspects of multidisciplinary design coordination. On the one hand, distributing design information among teams is done regularly through weekly or bi-weekly meetings.

However, the respondents highly emphasized on the importance of initiating these meetings as early as possible in the project, coupled with information seminars to determine project objectives, ensure full understanding, and establish an effective coordination scheme. According to the survey, the disadvantages of using paper, as replied by respondents, are printing time, cost, the time needed to locate information, and environmental aspects. While computer files were perceived as less costly and more easily communicated, issues of their acceptance as official documents were raised, since they can be changed and it is sometimes cumbersome to keep track of their multiple versions. On the other hand, design changes, are documented by the respondents in memos and "change advice notices" that are carefully filed. In this regard, the standard specifications will be followed by some firms for quality assurance and quality control, such as the British Standards. Among the first things to be checked by respondents when receiving a design change is its impact on design assumptions, the scope and area of change, approval by management, clarity of information, and budgetary implications.

## 2.4 Coordination Scheme Matrix

In this part of survey the participants were requested to identify the important milestones throughout their design at which they need to exchange information between them and the other teams. According to the responses received, a coordination scheme has been compiled showing at different design stages the information to be communicated and the purpose for which it is going to be used. In harmony with this scheme, common interrelationships among the participants throughout the design development process were schematically represented for building projects, level of involvement of each team is presented with the flow of the different design documents produced. This schematic matrix below can present several benefits as it could be used to determine which parties will communicate when a team introduces a certain change.

# 3. PROPOSED COLLABORATIVE DESIGN SYSTEM

The proposed collaborative design system integrates a client/server design environment with a set of collaboration tools. The information model is composed of three main parts:

(l) Building project hierarchy (BPH)
(2) Building components library (BCL)
(3) Design progress report (DPR).

The Building project hierarchy (BPH) stores all building data and represents this data as a hierarchy of active objects. Each object has its own information about its descriptions (e.g., values and documents), its design rationale and its communication paths. The Building components library (BCL) is a central storage of common building components that are needed to identify a building project hierarchy.

Table 1: Expected communication channels amongst departments

| | Department | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) |
| (1) | | * | * | * | * | * | * | * | * | * | * | * | * | * | * | * |
| (2) | * | | | | | * | * | * | * | * | * | * | * | * | * | * |
| (3) | * | | | | | | | | | | | | | | | |
| (4) | * | | | | | * | * | * | * | * | * | * | * | * | * | * |
| (5) | * | | | | | * | * | * | * | * | * | * | * | * | * | * |
| (6) | * | * | | * | * | | * | * | * | * | * | * | * | * | * | |
| (7) | * | * | | * | * | * | | * | * | * | * | * | | * | * | |
| (8) | * | * | | * | * | * | * | | * | * | * | | | * | * | * |
| (9) | * | * | | * | * | * | | * | | * | * | | | * | | |
| (10) | * | * | | * | * | * | * | * | * | | * | * | | * | * | |
| (11) | * | * | | * | * | * | * | * | * | * | | * | | * | * | |
| (12) | * | * | | * | * | * | * | | | * | * | | | | * | * |
| (13) | * | * | | * | * | * | | | | | * | * | | | | * |
| (14) | * | * | | * | * | * | * | * | * | * | | | | | | |
| (15) | * | * | | * | * | * | * | * | | * | * | * | * | | | * |
| (16) | * | * | | * | * | | | * | | | | * | * | | * | |

**Notes: Departments Codes**

(1) Project manager
(2) Technical review committee
(3) Contracts
(4) Specification
(5) Cost estimate
(6) Architectural
(7) Structural
(8) Electrical
(9) Special systems
(10) Plumbing
(11) Fire protection
(12) Infrastructure
(13) Roads and Highways
(14) HVAC
(15) Landscape
(16) Irrigation

To manage any design changes made to nominated object in the BPH and to keep track of the history of changes made by all disciplines, the Design progress report (DCM) procedures can be used. A host of collaboration tools is integrated into the client/server system for building design to improve design productivity and facilitate Internet based coordination. The implementation of the overall system is described in detail in the following sections. It is worth to note that Building project hierarchy (BPH) is project specific and allows for a unified storage and manipulation of building data that promotes consistency and avoids redundancy. All building components in the BPH are represented as smart objects that contain all their multi disciplinary design information. As such, the BPH is a spatial decomposition of the building in which each space contains information related to its architectural, structural, mechanical, and electrical designs. The architect can initiate a new project and create the BPH by simply answering four questions related to: New project name, Number of stages in the project, Number of disciplines in each stage, and Number of activates in each disciplines.

A corresponding default BPH with a roof component is created along with its underlying databases for the architectural, structural, mechanical and electrical designs. If the newly created building contains more than one floor, a stair component is automatically added to the BPH. To refine the initial BPH as per the detailed project information, the architect can change the default names of the components (nodes) and use the BCL to add new components to the BPH. Upon completion of this process, the system's main screen appears where the BPH is shown on the left side of the screen. Adding lower level components from the BCL to the BPH is simple as this activity relates to but a single design discipline. On the other hand, adding a higher level component (such as “stage”) requires adding various default nodes that relate to the corresponding architectural, structural, mechanical and electrical systems. The “electrical substation” for example is inserted initially as a default component from the BCL with its sub nodes, including the system nodes. When the “structural” node of the “electrical substation” space is highlighted, its associated structural tree is read from the “structural” database and automatically displayed at the bottom of the screen.

### 3.1 Managing Design Changes

One of the main features of BPH components is that they are active objects which are capable of automatically communicating changes made to their own values. To facilitate design change management, component related procedures monitor new and old values of any object attribute allowing designer to propose new values and obtain approval from other disciplines before doing a change, and track send/find changes made to the component. The change management module also includes other general procedures activated by the buttons shown at the bottom to provide effective tracking of all changes made, allowing designers to respond to proposed changes and implementing approved change proposals, and obtaining various reports on the changes made. These procedures improve coordination and keep project information up to date. When a designer uses the system, all changes made are stored in a temporary "today's changes" database. This information is then transferred to the project's "changes" database at the designer's request using the "add" button. The reporting system queries the databases to provide the user with useful information regarding pending changes and the history of changes made during the design evolution. Sequential query language (SQL) statements are used to automatically query the databases and obtaining the status of changes made by (or affecting) any design discipline.

### 3.2 Modified design process

Using the proposed system in a design office will require some changes to the traditional ways in which design tasks are carried out. The system can be used in two possible ways. First to have a representative (team coordinator) of each team use the system to daily update the BPH of a project with the designs made by all members of the team. To facilitate this use of the system, it will be necessary to provide individual designers with a form in which they list all design changes they made to any component. The team coordinator in each would collect these forms daily from team members and accordingly update the BPH. As well, the coordinator can assign members to respond to any changes affecting their designs that are received through the system. The benefit of this type of use is that the traditional design process will not change much, thus causing minimum disruption to designers' work habits. The secondly is using the proposed system is to provide all designers with client machines to access the BPH of projects. While a high level of design coordination can be achieved by this approach some training to be required to familiarizing designers with the system. In this case, the collaboration tools of the system can be used both at the individual team level at the interdisciplinary level.

## 4. MODEL IMPLEMENTATION

The proposed design Model is intended to facilitate effective communication and better integration among key project members, including architects, engineers, contractors and other related discipline. It serves as a platform where they can share the latest project or industry information and conduct online businesses. In so doing, the following objectives are achieved:

(1) Identify the activities of design discipline that would benefit most from a project parties.

(2) Develop a design prototype for the design of a project that allows effective communication and integration of construction processes in real-time.

The proposed design system is implemented on Microsoft Visual Basic 6.0 Enterprise Edition, which enables client/server developments. The choice of this programming language is a result of its object-oriented programming features, relative ease of use, ability to integrate with Microsoft collaboration tools rapid prototyping, and availability. At the core of the client/server system is a group of databases developed using Microsoft Access 97, which are directly readable by Visual Basic code. One project-independent database is used to store default-building components in the BCL. Implementation of the collaborative design system involved resolving a number of issues related to: 1) Establishing access control/access rights, 2) Ensuring the independence of each design discipline, 3) Saving and loading BPH trees, 4) Managing BCL components, 5) Specifying components at space boundaries, 6) Controlling the communication of changes, 7) Enforcing change proposals, 8)

Applying, sending. and discarding changes, 9) Facilitating designer response to changes, and 10)Providing automated warning.

Addressing these issues mandated iterative cycles of refinement to the model and substantial programming effort. It is worth noting that the building components library acts as a central repository of all building components needed to create a complete project. The library stores active components (small trees) from all three levels of the BPH along with their attributes. Changes to these attributes mean changes to the design that needed to be easily monitored; the attributes of any component are represented as visible objects in the vertical tree of the component. The tree for the "project" component is shown in Figure 3. The four main objects represent the architectural, structural, mechanical and electrical systems of the project. Similarly, components at a higher level include some general departments, in addition to the tasks of subsequent levels allocated for each department. A "project" component, for example, includes general tasks related to its base planes. Individual components stored in the building components library are used by the designer when building a BPH for a certain project.

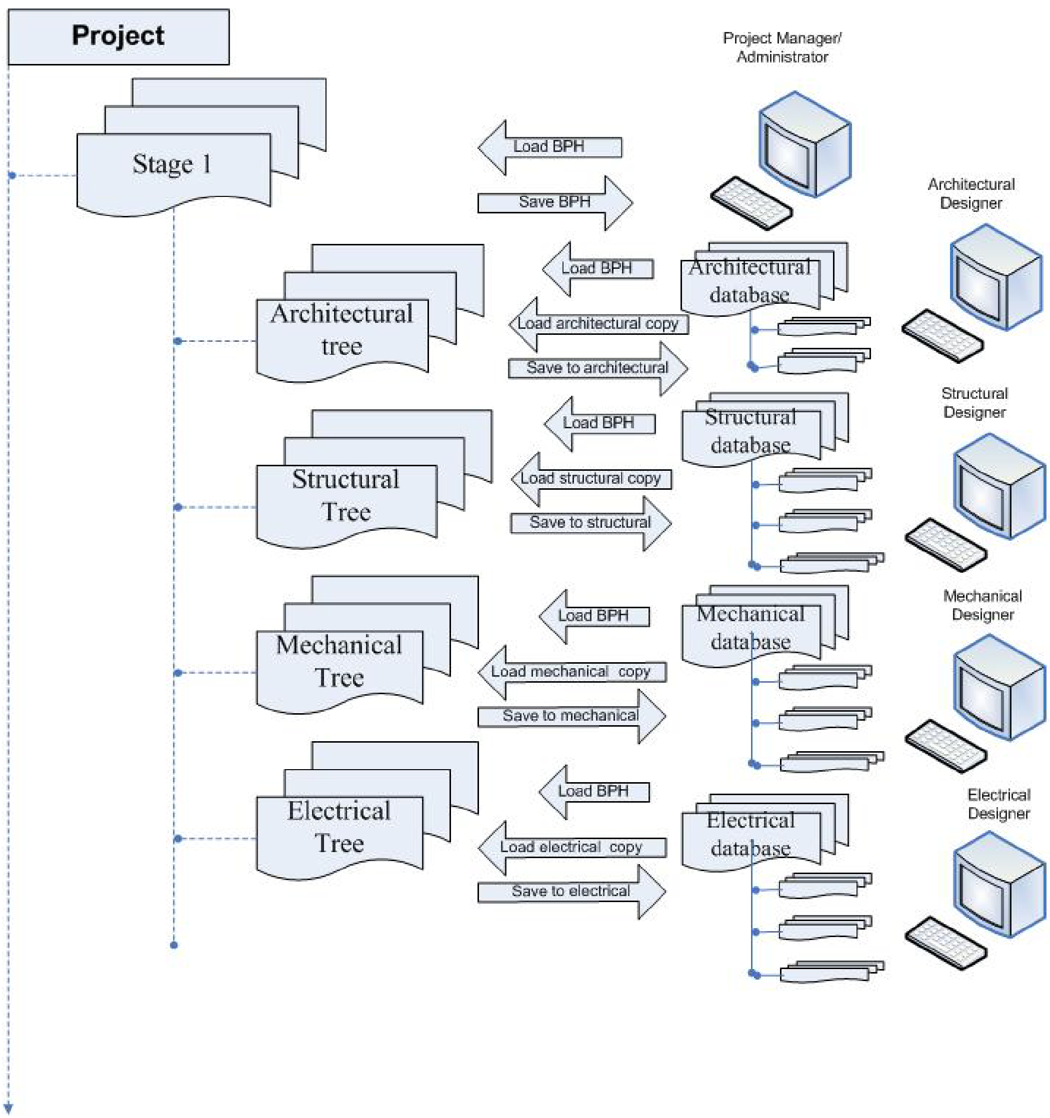


Figure 3: Project component tree

The main aim of the prototype model is to assist the project manger to carry on monitoring and controlling work in every project concerning his responsibility for and emphasizing that all required tasks from his side that is to say showing the overall progress of the project, achieving of milestones and deliverables and ensuring high quality of experimental and written output is achieved. Meeting the contractual obligations of the project in relation to reporting and financial matters and other issues that may arise during the overall planning of the project, organization, chairmanship and reporting of progress meetings and technical meetings, maximizing the dissemination activities of the project are required to optimize its impact and to resolve any conflict that arises in the project, through discussions with the relevant parties. The proposed prototype helps in satisfying above listed tasks.

## CONCLUSION

The design process of building projects and properly managing the changes are the main key aspects to control projects and ensure a consistent and well-coordinated design. This research presented an information model to store design information, record design rationale, and manage design changes. This paper presented a business process management model to aid in design coordination in engineering consultancy firms. The model provides practical recommendations and guidelines to avoid or decrease the effect of lack of coordination in design process. The proposed model incorporates a central building components library (BCL) that is used to create a complete building project hierarchy (BPH). The aim of BPH is to represent multidisciplinary design data within each building stage. In addition, each building component in the model has preset communication paths that help to automatically communicate activities changes made to any component to all affected parties. The role of the design administrator in this model is as a central coordinator. The model helps the design administrator to keep tracking of all changes, following up on permanently changes and coordinating proposed changes.

## REFERENCES


Dubois, A.M., and Parand, F. (1993) “COMBINE Integrated Data Model.” *Proceedings of CIBSE National Conference*, Manchester, UK, pp. 96-108.

Dufresne , T. and Martin, J. (2003). “Process Modeling for E-Business”. INFS 770 Methods for Information Systems Engineering: Knowledge Management and E-Business.

Hegazy, T., Zaneldin, E. and Grierson, D. (2001) “Improving design coordination for building projects – I: Information model,” *Journal of Construction Engineering and Management*, ASCE, Vol. 127, No. 7, pp. 322-329.

NIH (2007) “Business Process Management (BPM) Service Pattern,” <http://enterprisearchitecture.nih.gov/ArchLib/AT/TA/WorkflowServicePattern.htm> (Accessed 29 Nov 2008).

NTAID (2008). “Invoice Processing Procedures for Contracts”. <www.ntaid.ed.gov>. (Accessed 10 Sept 2008).

Osterwalder, A. (2004). “The Business Model Ontology - A Proposition In A Design Science Approach” Ph.D. thesis, University of Lausanne, **Switzerland**.

Seesing, P. (1996). “Distributing project control database information on the World Wide Web”. PM Network X, Vol. 10, pp 22-26.

Smart, P.A, Maddern, H., and Maull, R.S. (2008) “Understanding Business Process Management: Implications for Theory and Practice.” *British Journal of Management*, Vol. 20, No. 4, pp: 491-507

Teicholz, P. and Fischer, M. (1994). “Strategy for computer integrated constitution technology” *Journal of Construction Engineering and Management*, ASCE, Vol. 120, No. 1, pp:117-131.

Wikipedia (2010) <http://en.wikipedia.org/wiki/Business process management>. (Accessed 2 Jan. 2010).