Process management for collaborative building design

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ABSTRACT

Collaborative building design relies on people working coordinately to accomplish the requirements of a design project. Coordination is achieved by well organized, informed and communicating design teams. However, not all design teams in current design practice are well organized and well informed about where the project stands. This paper introduces a process management system that facilitates the management of the enactment of a collaborative design process. At the highest level, the process management system enables (a) the design teams to describe the design process that will be enacted by the team, (b) the enactment of the design process according to its process definition, (c) the management of the resources required for the enactment of the process. The paper also presents the findings of a validation and verification (V&V) study that is conducted to evaluate the effectiveness of the proposed system in the establishment of a collaborative design environment.

1 INTRODUCTION

In a competitive world there is always the need to improve the performance of design teams and stay ahead of the field. Studies on team performance have observed that some teams at the same stage in their development perform better than other teams, even of the same composition. Why is this? One of the main reasons is found to be a good work process. Researchers argue that collaborative process is an ideal case through which parties who see different aspects of a problem can constructively explore their differences and search for solutions that go beyond their own limited vision of what is possible (Gray, 1989; James, 1996). Collaboration is a situation where compromise is not needed. All participants can share in “winning” by collaborating on decisions (Gray, 1989).

Researchers suggest that design teams can achieve collaboration by employing a combination of techniques and technology. Observations show that a combination of these techniques and technology can support the design team’s internal communication, its external communication, the sharing of design information, and decision making.
However, they do not support teams in the management of the enactment of a collaborative design process. They do not help the design team monitor and control the coordinated enactment of design activities.

Studies in Business Process Management (BPM), Business Process Re-Engineering (BPR), Total Quality Management (TQM), Project Management (PM), Workflow Management (WfM) have for so long studied the management of the workflow of the business processes. They have developed strategies regarding: (a) the project organization - the alignment of resources to support project objectives, (b) the organizational strategy - the deployment of resources to support broader organization mission, objectives, (c) the life-cycle management – the management of projects as they fit into organizational cycles, (d) the project planning – planning of goals, strategies, and action to allocate project resources, and (e) the project enactment or implementation – the actions and constraints that are relevant to getting the project that has been planned actually carried out (Cleland and King, 1988).

Despite the power of the concepts and the history of successful applications of process management techniques in building practice, the process management strategies are not a panacea (Cleland and King, 1988). Rather they are tools which, when properly used under appropriate circumstances, can aid project teams in the achievement of a collaborative design environment. In current building practice, the successful implementation or enactment of process management strategies requires a leader or a project manager with a variety of managerial skills. The performance of a design process is depended on the skills or capabilities of the tools that they use. Project managers are viewed as conflict managers. This means that they should constantly be fire fighters. Project managers are required to continually be on the lookout for real and potential conflict situations and resolve them immediately (Stuckenbruck, 1988).

However, in order to achieve a collaborative design environment, members of the design team should also be able to monitor and control the enactment of a collaborative design process. The process management responsibility should be extended from a single-point authority to all the members of the design team. In this study, a distributed process management environment is required in order to facilitate the management and control of the enactment of a collaborative design process. This paper presents the model of a process management environment that can help all the members of a design team to participate in the control and monitoring of a process and the management of the resources required for its enactment.

2 CONCEPTUAL MODEL OF A PROCESS MANAGEMENT SYSTEM

At the highest level, the model proposed for a process management environment can be characterized with its support in three functional areas:
• Process modeling functions are concerned with the definition and modeling of the design process and its resources,
• Process control and monitoring functions are concerned with the management of the processes and the sequencing of the activities within each process.
• Process enactment functions are concerned with the enactment of activities and the interaction of users with applications and IT tools.

Figure 1: **Three-tier architecture of the process management environment**

The process management system (PMS) utilizes a three-tier client/server architecture (figure 1). Three-tier architecture defines three levels of computing:
• User Interaction Level: The user interaction level is the interface between the participants and the process management environment. Any number of individuals can participate in this environment. The interface enables the participants to receive information about the processes managed by the process management environment and respond to it.
• Process Management Level: Process management level consists of a service provider called Process Enactment Service (PES). PES is a unit that is responsible for the implementation of the functionalities provided to the participants and the coordination of their activities.
• Application Interaction Level: Execution of the process may require the utilization of other design, communication or evaluation application and information technology (IT) tools. Applications and IT tools are connected to PES at the application interaction level.

The client and server architecture of the PMS is implemented with JAVA RMI technology. Client side of the PMS consists of a graphical user interface (called
WorkCenter)(figure 2). The server side (called Workflow Engine) consists of a server with the remote methods invocation (RMI) capabilities.

Figure 2: Client interface in PMS – WorkCenter

2.1 Process definition and modeling

A process is a dynamic entity, which describes the hierarchy of activities, their performers, and the artifacts (products) that are required as input or generated as output of the activities. A design project can have various processes and sub-processes. A process is a running template. A template is a static and a reusable process definition. A best-practice design process can be turned into a template and can be used again for similar design projects.

Process modeling functions in the user interface enable the participants to create a definition of a design process. During this phase, a design process is translated from the real world definition into a formal definition. The resulting definition is called the “Process Model”.

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2.1.1 Process model

According to the proposed model, process enactment starts with the definition of a process that the design team plans to follow. Process model is the repository of information describing a process.

The process model describes all the information about a design process by encapsulating and relating the following categories of information: (a) activity, (b) product, (c) role, (d) agent, (e) direction, and (f) tool.

- **Activity.** Activity is a model entity that represents a unit of work. An activity is associated with input, output and intermediate products. An activity can be conducted by using a number of tools. Activities may be decomposed into subordinates.
- **Product.** Product is an input, output or temporary information that is used by one or more activities. Examples of a product are documents about the architectural program, user or client requirements, preliminary design documents, architectural specifications.
- **Roles.** A role is model entity that identifies a skill requirement that an agent must satisfy in order to perform an activity. During process definition a number of roles can be assigned to an activity. For example, for the development of detailed construction drawings, roles such as designing, drafting, reviewing, project management can be assigned to this activity.
- **Agents.** An agent is a model entity that is capable of performing roles and carry out activities. Agents can be individuals or other software programs that can perform an activity.
- **Direction.** Direction is a model entity that defines the objectives of the activities. It defines the constraints on an activity, and provides guidance. Directions may be rule-based, procedural, pre-post-conditions.
- **Tools.** A tool is a model entity that enables an agent to perform specific activities. Tools can range from applications for drafting to application for creating standard documents.

2.1.2 Development of the process model

A process can be defined in two ways. A design team may develop (a) a complete process definition, or (b) a dynamic process definition.

According to the first procedure, all the information about a process can be completed before enacting a process. This process definition is called “build time process” definition. All the information about a process and its components are known and defined before enacting it. However, the nature of a process may not always be known before enacting it. For example in preliminary design process, it is not always known who is going to be involved in the preliminary design process. A designer assigned to this task may be assigned to work on another project, and some other designer may take over this task. In another case, a preliminary design can be developed in accordance with some user requirements and later be changed due to changes in client
requirements. As a consequence of such cases, the nature of the process may not always be known before enacting it. The process definition may change during its enactment. As a result, a complete process definition may not always be provided to the system. However, a dynamic process definition may help design teams dynamically update the process definition during the enactment of the process. This process definition is called “run-time process definition”.

A process definition can be created in two different ways:
- By creating a new process definition
- By modifying a reusable process definition

A new process definition can be created from scratch by defining the activities and the relationships between them. The user can define an activity in two ways: (a) by selecting an activity from a list of activities, or (b) defining a new design activity. A dialog window (figure 3) enables the user to select an activity from a list of design activities. This list consists of a number of activities which are compiled from the AIA’s Project List (Haviland, 1994). All the activities are organized according to the seven phases of the construction process. Further, they are categorized into three areas as: (a) situation

Figure 3: PMS: Activity list

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assessment activities, (b) reactive activities, and (c) presentation/submission activities. Further, all the applicable activities are associated with the AIA’s standard documents.

Figure 4: **PMS: Selecting a standard document**

If the user prefers to define his/her activity, he/she can do it by providing the name of the activity, the phase it falls in, and the nature of the activity. The user can also associate any standard document with this activity by selecting from AIA’s standard documents list as shown in Figure 4.

The second method of creating a process definition is by editing an already defined process definition (process template). Process templates are reusable process definitions. They define the static behavior and properties of design processes. Reusable process definitions - templates, are created by defining the behavior and properties of the design processes.

2.1.3 **Modeling of the process definition**

For the enactment of a process, a process needs to be provided to the system in a computer usable form. A process can be defined and modeled using a variety of methods. Process modeling software available in the market use different techniques. They can express a process definition in textual or graphical form or in formal language notations.

In PMS, the user can create a process definition by using a formal process definition language. The formal process language enables the description of the activities within a process as well as the order and conditions for performing these activities. It creates a flowchart-like diagram and displays the hierarchy of the activities of a process and the relationship between them (figure 5).
2.2 Process enactment

The enactment of a process requires the creation of a new process. Enactment starts with the activation of the process. A user can create a new process by activating a process template. The template when associated with a project becomes a running process. The enactment of a process starts by associating the static process template with a project as shown in figure 6.

With the completion of the partial or complete process definition, the system components can start the enactment of the process in accordance to its definition. Enactment starts with the interpretation of the process definition. At run-time process definition is interpreted by the Process Enactment Service (PES). PES is a unit responsible for the creation and control of the operation instances of the process, for the scheduling of the activities within the process and for the invoking of the appropriate human and IT applications.

PES interprets the workflow of the process and identifies the next activity to be conducted. It adds work items to the participant work lists and help invoke application tools as necessary.
It assigns the resources (i.e., data, agents, and time) required for the completion of an activity. Whenever there is a change in the status of an activity, PES is activated and the workflow of the process is reinterpreted.

PES enables the enactment of a process definition by the following functions:

- Inform all the participants about the processes and subprocesses that will be conducted within a design project,
- Notify all the participants about the activities to be conducted for the enactment of a design process,
- Sign-on and sign-off agents to specific roles,
- Control process instances - process creation, activation, termination,
- Maintain and organize the workflow relevant data – store and pass relevant data to and from applications or agents,
- Trace the history of processes - when, by who processes were generated, what input, output and intermediate products were created.

In order to implement these functionalities, PES requires the definition of the running process. A running process, that is a process being executed is modeled in order to describe the status of the process. The definition of a running process is called a “Process Enactment Model”.

2.2.1 Process enactment model

The information regarding how a process model is being enacted is described with the development of a process enactment model. Process model describes how an already defined process definition is being enacted at a certain time. During the life cycle of the
design process, many process enactment models are generated in order to explain the current status of the process.

The development of a process enactment model serves two purposes: (a) it describes the current status of the process to team members that will monitor the design process, and (b) it describes the current status of the process to the system. Only with this information can the system determine which activity needs to be conducted next.

A process enactment model is created with the creation of four sub-models:

- Functional model represents what activities are being performed and what dataflows connect them.
- Behavioral model represents when activities were performed,
- Organizational model represents where (at which workplace) and who performed the activities.
- Informational model represents the data entities produced in a process.

2.3 Process monitor and control

Process control and monitoring functions enable the participants to inquire about the status of a design process. All the participants are provided an interface through which they can view the process management environment. The interface, called the Organizer, enables the participants to view the environment through various filters. The filters in the Organizer enable viewing of the process information according to user preferences. Some participants may want to view process information relevant only to their activities. For example, they may want to know only the activities assigned to them. Some participants (e.g. project managers) may want to view all the information about the process including the processes that are assigned to other participants.

PES presents the four different views of the process enactment model in different ways. The functional model, which is the model of the activities performed or needs to be performed within a process, is listed in “Activity List”. Each participant has an Activity List in his/her work center. When a participant is assigned to an activity, or when there is change in the status of an activity, PES updates the Activity List of all the participants assigned to that activity. PES transfers all the data and information about that activity to those participants.

Information model, which is the model of data entities and documents used or produced in a process, is presented to the participants along with information regarding the properties of an activity. All the data entities are associated with the activity that required or produced that data entity. The information model shows all the data including design documents, redlines, and remarks associated with that activity.

Behavioral and organization models present information about when and where (by whom) activities are being conducted or were conducted. All the activities of the users are recorded by PES. When PES compiles all these information about a process it
provides a record of the history of the process, and thus enables the control of the enactment of a process in regard to initial goals and requirements.

PMS presents four different views of the process enactment model in four file cabinets named: (a) projects cabinet, (b) processes cabinet, (c) templates cabinet, and (d) activities cabinet.

Projects cabinet lists the design projects that are monitored and managed by the workflow engine. A user can choose to view projects by using three different filters. A user can use a filter that shows: (a) all the projects, (b) all the active projects, or (c) the projects that were created by the user (figure 7).

Processes cabinet lists the processes of the projects managed by the system. Processes are associated with a design project and are listed in the Process List of an existing project. A user may choose to view the processes associated with a design project by using a filter that displays: (a) all the processes, (b) all the active processes, or (c) all the suspended processes associated with a project (figure 8).

Figure 7: PMS: projects cabinet

Figure 8: PMS: processes cabinet
Templates cabinet lists the templates recorded by the system. Templates are reusable process definitions. A template filter enables a user to view: (a) all the templates created and saved by the server, or (b) only the templates created by the user (figure 9).

Activities cabinet lists the activities of a process. The activities cabinet provide an “Activity List”. The “Activity List” shows the activities that need to be performed for the completion of a design process. A filter in the activities cabinet enables a user to view: (a) all the active activities, (b) all the completed activities, (c) only the user’s active activities, or (d) only the user’s completed activities (figure 10).

3 VALIDATION AND VERIFICATION STUDY

Studies conducted for the validation and verification of the system proposed for design process management helped the researcher to evaluate the effectiveness of the system
against the requirements and needs of the current building practice (Tuzmen, 2000). In the verification and validation (V&V) studies, a number of team leaders (e.g. project managers, associates) and member of design teams (e.g. senior architects) were asked to evaluate the performance of the PMS in the management of the enactment of a collaborative design process. The findings of the V&V study indicate that PMS can be effective in the management of the enactment of a collaborative process in professional building practice. However, the findings also showed that the conceptual model of a process management environment and its implementation (PMS) can be further improved mainly in the following areas: (a) planning of activities of a design process, (b) organization and management of design documents, and (c) tracking of progress of a project.

At the more fundamental scale, V&V studies showed that the current building practice could gain from the functionalities of a process management environment. A process management environment can enable all the members of a design team to track the progress of the design processes and the resources used for its enactment. Tracking of the design processes and resources can in return help teams coordinate their activities and their decisions and thus help them work in a collaborative design environment.

4 REFERENCES


