Collaborative Building Design

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Keywords
Collaborative design, process management, workflow management

Introduction

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 [1]. Why is this? One of the main reasons is found to be a good team 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 [2][1][3].

Much attention is now being paid to improvement of the design team process by establishing a collaborative environment in building design practice. Many scholars have prescribed various techniques and technology as ways of achieving collaboration in building design practice [4] [5] [6] [7] [8] [9][10][11][12][13][14]. A combination of these prescriptions does support design teams by facilitating one or more of the following: (a) team internal communication, (b) team external communication, (c) information sharing, and (d) decision making.

Only recently have there been studies that have provided the strategies for integrating these techniques and technology for the establishment of a collaborative work environment. Researchers from various areas of research have this intention. This includes studies in Business Process Management (BPM), Business Process Re-Engineering (BPR), Total Quality Management (TQM), Project Management (PM), Workflow Management (WfM). All of these studies share one common feature. They all contribute to the study of the management of the team process.

Despite the power of the concept and the history of successful application of process management techniques in building practice, the process management strategies are not a panacea [15]. Rather it is a tool which, when properly used under appropriate circumstances, can aid design teams in the achievement of a collaborative design environment. The successful implementation or enactment of process management strategies in building design practice requires a mediator, a facilitator, or a project manager with a variety of managerial skills. However, it is not only enough to support major facilitators in the implementation or in the enactment of a design process that is planned for that teamwork. The performance of a design process should not only be depended on the skills or

capabilities of tools that managers use to enact design processes. In order to achieve a collaborative design environment, members of the design team should also be given the support for monitoring and implementing of a collaborative design process. Team members should also have the ability to define, implement and track their personal subprocesses. Team members should also be able to monitor the process and be able to resolve the conflicts between their actions and other members' actions.

A distributed process management environment is required in order to facilitate the management and control of the enactment of a collaborative design process. Such an environment should enable the control and monitoring of the enactment of a process and the resources required for its enactment. This paper presents the conceptual model of a process management environment that is developed in order to establish such a process management environment. It also discusses the findings of a study that is conducted for the validation and verification of this conceptual model.

Conceptual Model of a Collaborative Design Environment

At the highest level, the model of a process management environment can be characterized as providing support in three functional areas:

- Process modeling functions, concerned with defining and modeling of the design process and its resources,
- Process control and monitoring functions are concerned with managing the processes in design projects and sequencing various activities to be handled as part of each process.
- Process enactment functions are concerned with the enactment of activities and the interaction of users with applications and IT tools for processing the various activities.

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 process and subprocesses. 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 business process. During this phase, a design business process is translated from the real world into a formal definition. The resulting definition is called a **Process Model**.

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 pertaining to the definition of a process. The process model describes all the information about a design process by encapsulating and relating the following categories of information:

- **Activity** is a model entity that represents a unit of work.
- **Product** is an input, output or temporary information that is used by one or more activities.
- **Role** is a model entity that identifies a skill requirement that an agent must satisfy in order to perform an activity.
- **Agent** is a model entity that is capable of performing roles and carry out activities.
- **Direction** is a model entity that defines the objectives of the associated activities, and defines any constraints to be respected by the activities, thus provide guidance.
- **Tool** is a model entity that enables agents to perform specific activities.

Process Enactment

With the completion of the partial or complete process definition, the system components start the enactment process, that is the execution of the processes in accordance to process definition. Enactment starts with the interpretation of the process definition.

At run-time process definition is interpreted by Process Enactment Service (PES). PES is a unit responsible for creating and controlling operation instances of the process, scheduling the various activities within the process and invoking the appropriate human and IT applications. It interprets the process definition and controls the instantiation of processes and sequencing of activities, adding work items to the participant work lists and invoking application tools as necessary. Further, PES interprets the workflow of the process and identifies the next activity to be conducted. It assigns the resources (i.e.. data, agents, and time) required for the activity. Whenever there is a change in the status of an activity, PES is activated and the workflow of the process is reinterpreted. In order to implement these functionalities of PES, the system develops the definition of the running process, called **Process Enactment Model.**

Process Enactment Model

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

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 are performed with sequencing, feedback loops, iterations, decision making, and triggering conditions.
- **Organizational model** represents *where* (at which workplace) and by *whom* activities are performed.
- **Informational model** represents the *data entities* produced in a process.

Process Enactment Service (PES) is a unit that is responsible for the development of these four views of the enactment model. Once the process definition is complete, PES executes the process according to the process definition. Execution of the process may require the utilization of other design, communication or evaluation application and information technology (IT) tools. In that case, necessary applications are connected to PES through an Application Interface.

Implementation of the Conceptual Model

The above described conceptual model of a process management environment is implemented by a Design Process Management System (DPM). DPM has a client and server architecture. It is implemented with Java RMI technology. Client side consists of graphical user interface, called WorkCenter (Figure 1) and the server side (called Workflow Engine) consists of a server with remote methods invocation (RMI) capabilities.

DPM can monitor and manage a number of design projects simultaneously. The users can create cerate new projects, provide project information and view the project history. DPM allows any number of clients to register themselves with the system and control the enactment of processes in various design projects. The Workflow Engine coordinates the creation and enactment of design processes of a project.

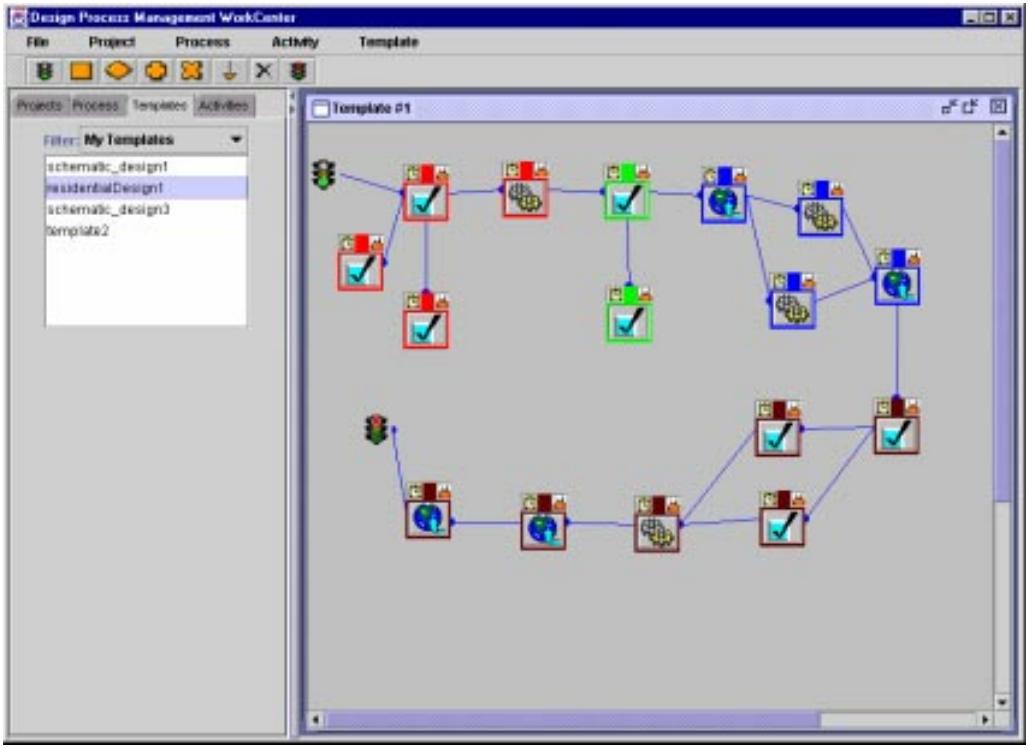


Figure 1:
DPM's WorkCenter

Development of a Process Definition

The enactment of a process requires the modeling of the design process, so that it can be interpreted and executed. A process model can be created in two different ways:

- Creation of a new process definition
- Modification of a reusable process definition

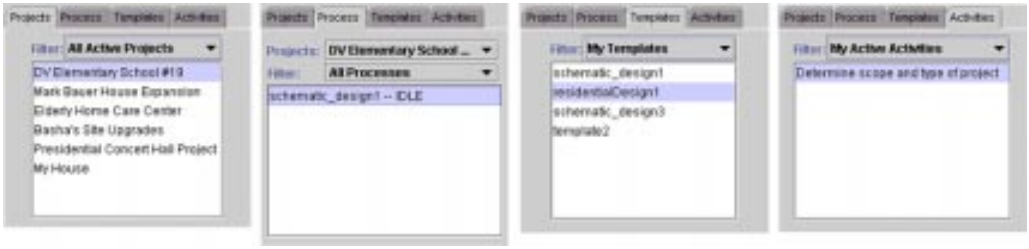
Creation of a new process definition

A new process definition can be created from scratch by definition the activities and their relationship with each other. The user can define an activity in two ways: (a) select from a list of activities, or (b) define their own. The WorkCenter enable the user to select an activity from a list of design activities which is complied from the AIA's Project List (AIA, 1991). All the activities are organized according to seven phases of the construction process.

DPM relates all the activities with the AIA's standard documents (if applicable). The activities are categorized into three: (a) Situation Assessment Activities, (b) Reactive Activities, and (c) Presentation/Submission Activities.

In DPM, process model is created using an Object-Oriented Modeling technique as shown in Figure 1. Processes are modeled with flowchart-like diagrams that displays the relationships between the activities that will conducted towards the completion of a design work. Process workflow can be

Figure 2:
DPM: Activity List



created or modified by six flow controls as shown at the toolbar of WorkCenter in Figure 1.

Enactment of a Process Definition

Enactment starts with the interpretation of the process definition. The enactment of a process requires the activation of the process. A user can create a process by activating a process template. The template when associated with a project becomes a running process.

Process Enactment Service (PES) controls the execution of an active (running) process. PES interprets the workflow of the process and identifies the next activity to be completed. It informs the participant of the activity by updating the Activity List in their user interface (WorkCenter).

The organizer (left side of the WorkCenter) is the file cabinet, which provide information about projects, processes, activities and templates (Figure 2). The Activities cabinet in the organizer area shows all the activities that are assigned to owner of this WorkCenter. A user can choose to view the Activities cabinet, as well as all other cabinets, by using filters that display only specific information regarding that cabinet.

Validation and Verification Study

The DPM system is designed to create a process management environment. A process management environment is believed to help design teams enact a collaborative design process by enabling the members of the design team to monitor and control the implementation of a collaborative process.

In order to verify and validate the proposition of the DPM system, the researcher conducted a verification and a validation study (V&V) with a panel of experts. The panel consisted of 12 individuals with firm and/or project managerial responsibilities at various architectural firms in the Phoenix Metropolitan Area. In the V&V study, the panels of experts evaluated the performance of the DPM system against the requirements and needs of their collaborating teams. Performance is evaluated by giving scores rated on a 5-point scale.

The conclusions that are drawn from the findings of the V&V study are:

- DPM system is less effective in helping groups in efficient allocation of resources to design tasks (Average is 3.8).
- The DPM system is effective in the creation and sharing of a project definition (Average is 4.0). However, most of the subjects found that the information collected for creating a project definition lacks some other information such the cost of the project, the feed of the consultants, the names and contact information of the consultants and clients, the start and completion date of the project.
- DPM system is effective in the allocation of resources and time for an activity (Average is 4.4).
- DPM system is effective in tracking the progress of a project (Average is 4.4).

- DPM system is effective in helping groups have a clear understanding of the objectives of the design group (Average is 4.0) - in helping teams state and share their missions and objectives.
- DPM system is effective in helping groups have a coordinated vision of a situation (Average is 4.3) - in helping teams have a coordinated view of how the project is doing, what problems the group faces, and what objectives and goals they have.
- DPM system is effective in helping groups have a collaborative decision making environment (Average is 4.0) - in helping teams make design decisions through discussion and consensus.
- DPM system is effective in establishing a shared leadership in design groups (Average is 4.0) - in helping teams share leadership roles with other individuals in the design group.
- DPM system is effective in helping a group resolving conflicts in a design project (Average is 4.2) – in helping teams detect and resolve conflicts among design decisions.
- DPM system is effective in helping groups in the assessment of group performance (Average is 4.8) - in helping teams measure the group performance in terms of its effectiveness and efficient.
- DPM system is more effective in the utilization of industry or customized standard document (Average is 4.8).
- DPM system is more effective (Average is 4.6) in the planning and scheduling of design activities. Some subjects (15% of subjects) required DPM's integration with currently available methods for planning and scheduling (e.g. Microsoft Project).
- DPM system is more effective in the organization of the design documents (Average is 4.7).

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