THE EFFECTIVENESS OF A DISTRIBUTED PROCESS MANAGEMENT ENVIRONMENT FOR COLLABORATIVE DESIGN

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Abstract. This paper introduces the constructs of a distributed process management environment (DPME) which was designed to stimulate collaborative design by supporting: (a) the communication of team members, (b) the shared creation and discovery, (c) shared understanding, and (d) self-sustainability of effective team performance. An evaluation study was conducted for assessing the effectiveness of the DPME in meeting the conditions required for collaborative design. In the DPME evaluation, a group of experts (N=13) were asked to discuss the current needs and expectations of the design teams from an effective collaborative design environment by identifying the capabilities and limitations of the currently employed collaboration methods and tools. The findings of the evaluation study illustrated that the design teams require to work in a collaborative design environment which not only allows the exchange of information regarding the artifacts being designed but also the communication of interrelated team members, the creation of a shared understanding of the team's vision and progress, the shared creation and discovery of artifacts and vision, and the monitoring and controlling of effective team performance.

1. Introduction

The building design practice is comprised of a number of design experts who through sharing their ideas, knowledge, and experience achieve an effective design practice. The aim of the design teams is to work in environments that would support collaborative design and thus allow all the members of the design team constructively search for solutions that would go beyond their own limited vision of what is possible.

The literature consists of a number of studies and theories which have contributed to the development of effective collaborative design environments. The majority of these studies amplified the existing communication models and freed design teams from time and space constraints (Bhat et al., 1993; Dave, 1995). Prime examples of resulting technologies are the group communication support systems (GCSS) and group information support system (GISS) (Blueline, 1999; Buzzsaw, 2000). Some of the proposed models
of collaboration enhanced the communication models by allowing teams to create a shared understanding and vision (Kalay, 1997; Knapp and McCall, 1996). Researchers proposed various methods and techniques for supporting joint discovery and authoring of design solutions (Khedro et al., 1993; Maher et al., 1993). Furthermore, many studies have focused on the shared discovery of the processes that the team opts to follow to arrive at its objectives (Cichocki et al., 1998; Heintz, 1999).

On the other hand, an analysis of the literature on collaborative design environments showed that only few studies have focused on the problem regarding the monitoring and controlling effective team performance. Unfortunately, few conceptual models in the literature have proposed an environment that would distribute the power and responsibility for managing effective team performance to all the members of the design team. It would appear that research has not focused on the design or the development of collaborative design environments that would allow all the members of the design team to plan their processes, enact according to their plan, monitor and influence their performance in following the planned processes, and prevent themselves from deviating unconsciously from their desired performance.

2. The Distributed Process Management Environment (DPME)

The researcher designed a distributed process management environment (DPME) for meeting the conditions required from an effective collaborative design. The aim of the DPME is to support: (a) the communication of team members, (b) the shared understanding of the team’s vision and insights, (c) the shared creation of design solutions and discovery of the team’s vision, and (d) the joint monitoring and controlling of design processes for sustaining effective team performance.

2.1. TEAM COMMUNICATION

The DPME is intended to support collaborative design by allowing the asynchronous communication of the team members with a client-server architecture. In the DPME, each member of the design team has his/her own workspace – the client application called the WorkCenter. The server is an application, called the Workflow Engine. Since design teams may consist of a number of members, the DPME can have a number of clients at a certain time. The DPME was required to run on any computer platform the team members happen to have. To achieve this objective, the server and client architecture was implemented by the JAVA Remote Method Invocation (RMI) technology.

In the DPME, a user may communicate with the server and thus consequently with others clients by performing two major tasks: (a) check-in
information (send), or (b) check-out information (retrieve). The server is responsible for storing and managing the checked-in information.

2.2. SHARED UNDERSTANDING AND VISION

In the DPME, all the members of the team are informed about the processes that the team plans to follow. Each team member also shares the same conceptualization of how the team is performing in following the processes, completing its tasks, and applying its resources.

To support the creation of a shared understanding and team vision, the DPME extended the information models described in studies by Fenves (1990), ISO (1992), Kalay (1997), and Kim (1995). In DPME, a design team can communicate asynchronously by exchanging information captured in three information models (a) a project model, (b) a process model, and (c) a product model.

2.2.1. Project Model

The project model consists of information regarding (a) the project name, (b) project number, (c) project description, (d) project type, (e) building type, (f) project location, (g) the client’s contact person, (h) the contact person in the design team, and (i) the processes in a design project (the process model) (Figure 1).

![Project Model](image)

Figure 1. Information captured in the project model.

2.2.2. Process Model

In the DPME, the design team shares the information regarding the design processes by constructing a plan which captures information regarding (a) the activities in a design process, (b) the products required as inputs for or outputs of these activities (the product model), (c) the resources to be employed, and (d) the standards to be used for guiding the team in the enactment of these activities.
In DPME, the activities and their sequence are presented by an activity-flow diagram (Figure 2). An activity-flow diagram consists of five entities: (a) Start node, (b) Activity, (c) Relation, (d) Condition node, and (e) End node.

Figure 2. Description of the process plan by an activity-flow diagram.

Figure 3. Nature of the activities in a design process

In an activity-flow diagram, the process starts with a start node and ends with an end node. A directed line illustrates the sequence of the activities and indicates that an activity at one end of the line should be followed by an activity at the dotted end of the line. The activity-flow diagram illustrates the conditions required before the initiation of an activity by the help of the three condition nodes: (1) or, (2) and, (3) condition. An activity node represents an activity in a process and captures information regarding (a) the phase of the process (see Figure 3), (b) the nature of the activity (see Figure 3), (c) the
documents required for or produced as a result of that activity (see Figure 4),
(d) the participants – the members that are required to conduct it (see Figure 5),
and (e) the date for completion (see Figure 5).

2.2.3. Product Model
In the DPME, the inputs required for and the outputs (intermediate or final) created as a result of an activity are captured in a structure, called the product model. The product model contains information regarding (a) the design decisions or alternatives (e.g., drawings, CAD models, images), (b) the semantic information, such as the intention and rationale behind a decision (e.g., redlined drawings), (c) the performance and implications of the design decisions or alternatives (e.g., evaluation routines, performance models), and (d) the reactions to the proposed design decision (e.g., redlined text documents, redlined drawings). A document tree structure displays the contents of the products model. The product model is created by checking-in documents into the system. The information captured by the product model is viewed by checking-out documents from the system.
2.3. SHARED CREATION AND DISCOVERY

The purpose of the DPME is to support (a) the shared creation of design solutions and (b) the discovery of the path by which the team envisions arriving at its objectives and goals. The DPME supports these functionalities by allowing the team to asynchronously make decisions in distributed workspaces.

2.3.1. Shared Creation of Design Solutions
The researcher envisioned the DPME as an environment in which each member of the design team works in his/her own workspace and makes decisions in mutual agreement with other members. The DPME allows a team member to create or discover new design alternatives in isolation, and modify or influence existing ones by providing positive or negative feedback. It gathers all the outcomes of these tasks and allows the sharing of design alternatives, the rationale behind them, and the feedback given to them.

2.3.2. Discovering the Design Processes
In the DPME, all the members of a design team can discover and define the processes that will guide them to their objectives and goals. It supports process planning by allowing the identification of (a) the activities in a process, (b) the products required for or produced by the activities, (c) resources required for the completion of the activities, (d) the dependencies between the activities, products and resources, and (e) the standards regulating the enactment of the process.

DPME allows some or all of the members of the design team define the plan of a process by allowing them to construct a simplified view of the process, called the process plan. In DPME, a design team can use and reuse the process plans that were proven to be successful in meeting certain objectives and goals of the team. The design team can construct a reference process model, called a template, which describes the process that the team plans to follow in similar design projects.

2.4. SUSTAINING EFFECTIVE TEAM PERFORMANCE

The purpose of the DPME is to support sustainability of effective team performance by enabling the participative management of the process enactment. DPME allows design teams to (a) discover the processes they want to follow in arriving at their objectives or reuse the reference process models that they or others have developed through direct experience, (b) follow the planned processes, (c) monitor the performance of the team, and (d) influence the performance of the design team.

2.4.1. Enacting the Plan of a Process
DPME allows design teams to enact according to the plan of the processes by having the capability to (a) detect the correlation between the processes being enacted and the plan, (b) identify which part of the plan needs to be conducted next according to the plan, and (c) inform the members of the team of the tasks, design documents, standards, and time resources.

The team can start the enactment of a process by activating it. The activation of a process requires the association of a process plan with a design project monitored and managed by the DPME. The New Process interface (Figure 6) allows the activation of a process.

![Figure 6. Activation of a process in a design project.](image)

After the activation of a process, the DPME interprets the plan of the process and identifies the activity(s) following the start node. The resource interpreter identifies the resources (time and human resource) allocated for the enactment of first activity(s). It identifies the team members that were assigned to this activity (participants of the activity), updates the list of activities that were indexed for each team member and feed all the documents related to that activity to each participant’s workspace.

2.4.2. Monitoring the Enactment of a Process

DPME enables the monitoring of the enactment of the design processes by allowing the observation of (a) the progress of a process (progress view), (b) the team’s resource usage in completing a process or activity (resource usage view), and (c) the products (product view).

DPME constructs a progress view by determining which processes and activities are completed, suspended and not initiated at a certain time frame. The Process tab in the organizer allows the user to monitor the progress of the processes in a design project by the help of three filters: (a) All Processes, (b) All Active Processes, and (c) All Suspended Processes. The activities tab allows the team to view the progress of the activities and the next activities needed to be completed by a team member (Figure 7).
The DPME constructs a resource usage view which describes the team’s time and human resource. It describes who has participants in which process and activity (who did what), how they have contributed to them (what products they produced), and how much time they have spent when contributing to those processes or activities (how long did it take).

2.4.3. Influencing the Enactment of a Process

In the DPME, the members of the design team are given the authority and responsibility for influencing the enactment of a design process by (a) feeding additional information or knowledge and (b) providing negative or positive feedback. By providing additional information or knowledge, a member of the team affects the enactment of the design activity. After monitoring the progress view, the resource usage view, and the product view, any member of the team can give feedback and thus share his/her thoughts about how the team is performing. In DPME, the design team can give positive feedback for supporting the current trend; or give negative feedback to declare his/her discontent or to request a change in the trend (see Figure 4). DPME allows the free flow of feedback and sharing of feedback among all the members of the team.

3. Evaluating the Effectiveness of the DPME

The study asked a group of experts to discuss and rate on a five-point scale the effectiveness of the DPME in meeting the conditions that the design teams currently expect from an effective collaborative design environment. The group consisted of 13 experts (N=13) who are considered to be experienced in and knowledgeable regarding the current needs and expectations of design teams in the building design profession.
TABLE 1 shows the conditions that the experts were expecting from an effective collaborative design environment. The experts stated that such an environment should allow all the team members to make decisions in their isolated workspaces and coordinate those decisions with others being made. The experts had conflicting ideas about who should have the authority and responsibility for managing and sustaining the enactment of design projects. Some argued that all the team members should be able to introduce solutions to conflicting situations without the approval of a higher authority. Others argued that the authority should be given only to a selected management team. However, all agreed that an effective collaborative design environment should allow all the members to act according to the team’s game plan. All the team members should have an understanding of the progress and consequences of their work. They should influence the enactment of processes by providing continuous feedback.

The findings of the DPME evaluation showed that the DPME effectively supports (a) the team communication, (b) the creation of a shared understanding of insights and vision, (c) the shared creation of design solutions and discovery the team’s visions, and (d) the sustainability of...
effective team performance. The effectiveness of the DPME was rated positively (Mean above 3.77 and standard deviations less than .63) (see

TABLE 1). The experts also recommended several enhancements to the DPME. They suggested that the DPME allows the management of changes in design decisions by enabling them to monitor and control of such changes. It also allows the easy search for and retrieval of different versions of design documents according to content and context.

References


