Management system for a Virtual Cooperative Project

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The paper presents on-going research aimed at the support of the management of building projects and the aid cooperative design. Today, The use of systems adapted to the cooperative design assistance for the building domain is complex. This results from the complexity of the cooperative work (difficulties in tracking actor's work, lack of most of the required information, coordination problems, implicit nature of most of the construction activities, etc.) The paper will briefly review two data exchanging modes that we had defined. After, on the basis of this concept of cooperative design we describe a new model of a virtual environment aimed to takes into account the relational organization of the project and the semantic meaning of works. This research represents a new approach because it not based on management of documents but on all data relative to works. Finally, we use this new model for defining a design-aided tool, to deduce advantages and limits of the "Virtual Cooperative Project". This system lets geographically dispersed project actors model the project context of a building. More specifically, it allows interpreting, using and exchanging project works in a centralized virtual environment during the building life cycle. This system uses IFC objects which associate in the same model the semantic and the 3D representation of building works.

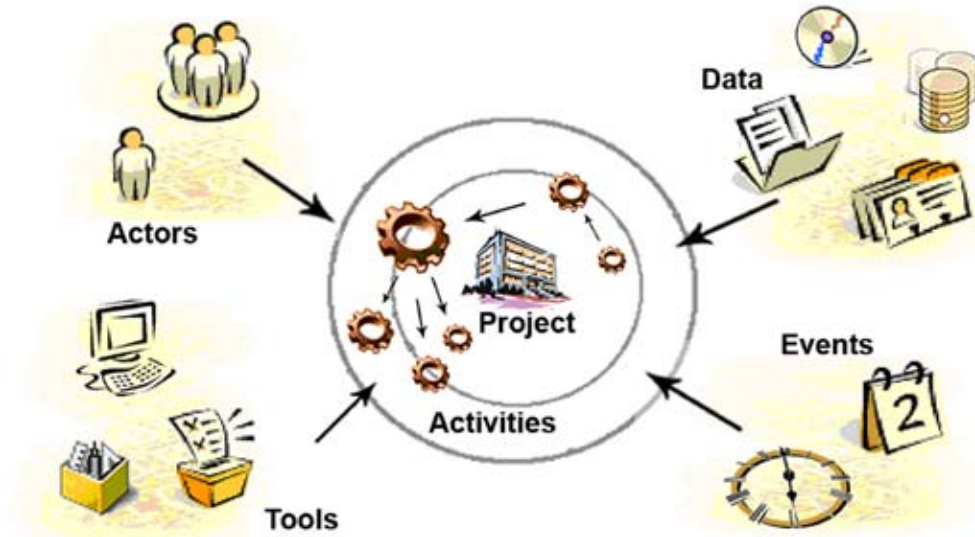**Keywords***: Cooperation model; cooperative work design; project management; digital mock-up.*

1. Introduction

Design is a problem solving activity based on multiple and diverse sources of expertise. Specifically, building design is cooperative in nature due to the large number and diversity of participants that are involved in most design projects which are characterized by their complexity and the non-standard nature of the production (Clough and al. 2000). Points of view are often shared between actors, and decisions about different project aspects are submitted for common approbation. In order to enhance the learning for actors participating, it is necessary to provide them a complete platform managing project data.

In construction projects, design process management is a discipline that promotes an integrated approach to the creation, capture, access, and use of a profession's domain knowledge on their design activity. Design process management involves also se-

curing, coordinating, combining, retrieving and distributing knowledge. The global organization of the design process allows actors to have a good vision of the building project. Actually, most of the management design tools in construction are unsuitable because they don't sufficiently take into account the cooperative dimension and the implicit nature of building designer work (Godart and al. 2001). It does not enable them to treat all the semantics of the works especially the one relative to cooperative design (difficulties in tracking actor's work, lack of all the required information, coordination problems, etc). So, in this paper, our objective is to define a tool that must help designers to obtain maximum project context data and structure works semantic meaning, which allows good objectivity in decision evaluation. This will be able thanks allowing actors to get reliable data concerning the state of the project in order to determine what the actions to be carried out are.

This paper will briefly review the data exchanging modes of cooperative design process. It will then illustrate one vision of the digital project deduced from the analysis of the IFC object model "Industry Foundation Classes" imported for construction. After that we justify the interest shown in a new model of cooperative design where the relational organization of the project and the semantic meaning of works are taken into account. Finally, we use this new model for defining a design-aided tool, to deduce advantages and limits of the "Virtual Cooperative Project".

2 Data exchanging modes in cooperative design project

Design activity corresponds to a sharing of a space, which contains common and shared objects. This space is always extended by individual contribution in cooperation and by collective contribution in collaboration (Lonchamp 2003). This co-production is

structured by actors' coordination. (Dillenbourg P et al., 1995)

Design project is an activity of reciprocal prescriptions. A great number of heterogeneous variables and events are taken into account to design and to construct building (Barros de Sa et al. 1994). Consequently, these activities are often conducted in a collective way. Actors (characterized by their capacity of action) use more and more tools to assist their work, and technologies to structure their exchanging of data (allotted and produced).

In construction, there are two types of cooperation approaches in exchanging data:

- The first one is founded on documents and exchange files. It is structured by several data exchange practices: manual management of exchanges (sending disks, maps, exchanges by electronic Email, exchanges through PDM, cPDM , etc.) Some of these practices save time and are efficient through big projects, etc. Some others show little trace of sharing and are submitted to precise structuring rules for drawing up documents, etc.

- The second cooperation approach is based on the use and the manipulation of the semantic meaning of a project. It constitutes an experimental practice which consists of sharing a digital mock-up and modeling building projects with interoperable objects. This practice has not yet shown its efficiency, but is being followed with great interest.

Cooperative systems dedicated to the first approach offer a view taking care of physical organization of data that not reflect in any way the social organization of a project. Carrying on the dimension associated with an alternative structuring information mode (Dourish, P. et al. 1999) we think that is a way to follow for the definition of a new cooperation model proposing an adaptive and navigable vision of the project. This model will constitute the basis of the Virtual Cooperative Project, which is taking care of the data exchange by means of semantic meaning of works.

3. The model of the Virtual Cooperative Project

We focus our research in the approach of sharing and exchanging data with model notions of construction description, using domain knowledge. These models are at to basis of the common D.M construction. So, exchanging data in not based on documents but on their contents and more precisely on the works and the spaces that they describe. These works (walls, windows, etc) are not defined only by graphic representations but also by their features such as the composition of a wall, surface of a local, etc. According to this constitution, we had worked on identifying the capacity of the current IFC digital mock-up[1] (Liebich 2004) to structure the cooperative design activity. We distinguish that IAI had adopted many STEP[2] industrial standards, but their building sector adjustment raises some data exchange problems about:

- Tracing actor actions: IFC model show tangible blanks about intervention traces and the actor role definitions in the development process of a digital mock-up. Until today, we cannot indicate whether an object has been proposed, modified, deleted or validated by an actor.

- Setting up project evolution cycle in digital mock-up: During the design of the different objects making up the project, the IFC model doesn't permit us to assign them the progression levels defining the project evolution. The project objects incur evolutions, transformations and adaptations that are not expressible with the IFC model. The current model makes reference to changes only in general phases and not allow to re-use a previous update of works. So, we cannot know if an object is under design, under modifi-

1   We make the hypothesis that IFC objects (IAI project) are currently the more successful to constitute the basis bricks of the shared D.M realization in the building domain; but that not exclude the discussion about their validity.
2   Standard for The Exchange of Product data model: are international computer exhaustive descriptions of physical and functional features of any industrial product type during its life cycle.

cation or already validated.

- Defining semantic meaning used to design works: In the latter IFC update (IFC 2.X 3 release) (I.A.I. 2007), we cannot attach to every object its manufacture constraints, its rules for setting up, its physical proprieties, its regulation rules, its structural characteristics, its plastic qualities etc.

Thus, IFC model shows lacks relative to the cooperative dimension. This model must takes in account the flexibility of current practices and operating mode of project building: so we interest in a new model of cooperative design where the relational organization of the project and the semantic meaning of works are taken into account. These works are the main focal point. In fact, every project work holds some relation with its 'environment': with the actors who designs it, the documents that represent it and the activities that create it.

The implicit character excelling in the act of building a work implies that it is the actor and not the system who must take the initiative to carry out a coordination or regulation action of the group activities. Therefore, it's imperative to allow actors to get reliable data concerning state of the project in order to determine what the actions to be carried out are, also to get a vision of the development of the project in conformity with the reality.

We propose a cooperation meta-model that allows the taking into account of the existing relations between the elements of a project (actors, activities,

documents and objects). The instantiation of the objects allows the definition of the VCP. The Virtual Cooperative Project (VCP) is a project that we have initiated in the co-designing domain, having as a target the definition, the design and the realization of a model able to assist cooperative design in architecture using works (instantiation of objects).

A work represents a physical object making up the basic brick of a digital mock-up. This object is characterized by its geometrical and topologic data but also by its semantic meanings. Every work belongs to a class, possesses attributes, relations and is set according relative constraints. Works maintain four types of relations:

- The relationship between activities and works is distributed in time and shows the works' evolution during the building's life cycle. It is a dynamic relationship. For example: a project generates a digital mock-up; a digital mock-up evolves in a phase; tasks and requests concern works, etc.
- The relationship between actors and works is referential and associative. It indicates actor's interventions on works. It is a dynamic relationship and allows us to distinguish each actor's design work and reflect point of view. For example: an architect creates, modifies, deletes, or validates a work, etc. The study of the relationship between actors and works allows us to identify the relevant semantic meaning related to building works, for each actors' profession. So we have used the classification of works' semantic meaning and the several actors' professions, to set up a table identifying semantic types that interest mainly each actor.
- The relationship between documents and works is relative to the data specifications. It is a static relationship. For example: a document describes a category of works, a work makes reference to some documents, etc.
- The relationship between works is relative to their design. We distinguish those linked to their development and those linked to their space organization, as a dynamic relationship. We dis-

tinguish too those linked to the nature of the relationship between physical parts, as a static relationship. For example: a wall is set on a floor, a beam holds a column, a window is situated in a wall, a digital mock-up evolves in another update, a wall is subdivided in to several walls, etc.

4. A management system in design building

To manage a project 'type VCP', we use this new model for defining a cooperative management system called Bat'Group. This system lets geographically dispersed project actors model the project context of a building. More specifically, it allows interpreting, using and exchanging project works in a centralized virtual environment during the building life cycle. This system uses IFC objects which associate in the same model the semantic and the 3D representation of building works. Bat'Group have a graphic interface named Bat'Map which aims at total structure of the project context using nodes and links.

Bat'Map allows users to initiate a cooperative project environment by identification of actors, activities and documents. When the first update of the digital mock-up is created ('.ifc' type file), a coordinator proceeds to its download from a Bat'Group web platform. The system interprets (thanks to a parser) IFC's data relative to the works; visualizes digital mock-up using a "composed work" node and

the works composing it using a "simple work" node. When deposing this first version of the digital mock-up (for example by the architect), the creator will have an automatic link with all works making this digital mock-up.

When updating digital mock-up, the works evolve. So to identify the new modifications, we adopt 8 states relative to the works. Every work evolves and has different states. A node state represents one work evolution context and is represented by different icons. We have used colors to distinguish cooperation states: inactive object, active object, an object submitting a problem and an approved object. Then, we have used different icon forms to distinguish development states: a suppressed work, a new work, a modified work and a work without change.
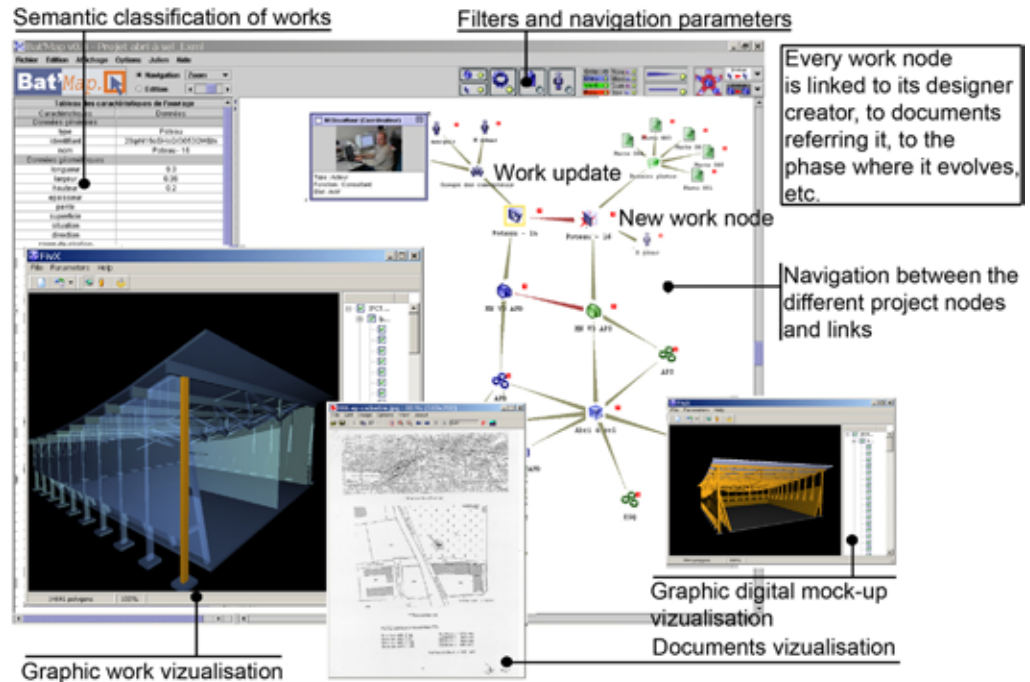
Every digital mock-up update, the system proceeds automatically with identifying changes to works, thanks to a comparison between the ".ifc" data. Then, the system proceeds with linking works to the actor (author of the new update) as the one responsible for the suppressed, modified and new works. Works without change are linked to the last update designer, etc. These links between actors and works allow action tracability during the project design.

We conduct two experiments to test the Bat'Map capacity to assist cooperation design in a building project. The script adopted for the experiments de-

Activities are structured on project phase, task and coordination request. Actors are structured on project team, group and user. Documents are structured on folder and document. Works (composed and simple) and spaces compose the objects.

Semantic classification of works

Filters and navigation parameters

Every work node is linked to its designer creator, to documents referring it, to the phase where it evolves, etc.

Work update

New work node

Navigation between the different project nodes and links

Graphic digital mock-up vizualisation

Documents vizualisation

Graphic work vizualisation

scribes the design of two buildings (a wooden salt store and a building extension in France). Actors coordinate themselves in a distributed asynchronous mode. The script steps cover: the building evolution throughout analyzed phases, the cooperation activities solving design problems, the digital mock-up updates, the validation of phases, etc.

As a result of experimentations, we notice firstly that the representation of cooperation design context of a building permits a global view of the project: actors, phases, tasks, documents, works and relations between these concepts. Secondly, comparison of several digital mock-up updates during all the phases of the project allows designers to save time when they have to identify changes between updates. Bat'Map allows users to have a clearer view of the building life cycle, and to trace all actors' actions on works and documents. This constitutes a

great assistance to the project management. Thirdly, semantic meaning management of works represents a design aid. The fact that designers use all the documents and data relative to a given work, allows for good objectivity in their choices, and enables them to take into account a maximum constraint.

5. Conclusion

This paper presents a new approach of cooperation aided-design, which proposes a new data organization of building context, by the representation of the existing relations at same time on the site, and also inside the project. This management system provides a set of processes, functions and databases placing the IFC at the heart of the project context. The main advantage of using these objects is to provide actors

with structured data related to the semantics and the 3D representation of building works.

The identification of the different states of works allows actors to have a clearer idea of every work and digital mock-up statute. The semantic meaning thus obtained permits actors to adapt their vision of the design evolution and to avoid wrong decisions. The results of the study also show that the visualization of the different digital mock-up updates allows us to have a trace of actors' actions (author, date and modification objects), saves time in the identification of changes and allows us to specify the respective responsibilities linked to modification, creation or forgotten works.

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