Towards an integration of the cooperative design context in collaborative tools.

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Abstract: In a design project, the actors cooperate to achieve a same objective, which can be the production of a document, a manufactured product, a plane or a building. The role of a cooperative project management tool is to offer each actor not only a good vision of the project development but also the extent of his action potential. The cooperation context of a design project is a relational organization where each actor keeps up specific relations with other people (designers, project managers, etc.) but also with documents and activities. This organization has to be represented in the project management tool to give each user an adaptive vision of the project organization and development. We propose a representation and a visualization of such a context, which characterizes each design project.

1 Introduction

The design and more particularly the design project management are social and professional activities characterised by a specific cooperation context. The available collaborative tools are not adapted to this context. Indeed, the cooperative design (or co-design) – contrary to the collaborative or distributed design - requires a cognitive synchronization based on "not planned" activities that we qualify of "implicit" activities. Autonomous actors, belonging to one or more companies, realize these activities with varied and complementary competences. In this group, the actors cooperate in order to achieve a common objective, which can be the production of a document, a manufactured product or a building.

In this cooperation, the role of a tool is to allow the actors to have not only a vision of their work development but also to increase their action's potential. The existing tools, commonly called "workflow", are based on cooperation and coordination models where the activity must be explicit. They are adapted to the definition of industry or administration processes.

The objective of the work presented in this article is to propose a general model of representation of the cooperation context adapted to the co-design. The application field is architectural design. This model is based on the semantic expression of the relations existing between the elements of the project. It allows us to describe the context of a project as a hyperdocument in which each actor can navigate. The hypermedia is visualized as a graph where the visual representation of each element brings information to the user. The objective of this visualization is to suggest to the actors a "project image" adapted to their implication in the collective activity.

In the first part, we will describe the framework of the cooperation in design as well as the characteristics of the cooperation in architectural design. Then we will present respectively in the second and third part the solutions which we bring in terms of meta-model and visualization.

2 The cooperative design context.

The collective design of an object – a work or a product - requires the participation of many actors with different but complementary methods and competences. To organize this activity, we have to consider the concept of “project” rather than those of “object”. Then, we are placed in the field of “cooperative” project management, where the design object evolves according to the exchanges and the interactions between the project actors.

2.1 The social organisation of the design project

The study of coordination modes, which organize the actors’ activities in the design process, reveals some critical elements of the work in a group:

- The place of the actor in the design project: the implication of each actor varies according to his role.
- Knowledge management: knowledge capitalisation (on the present project or on past projects) is necessary to offer the actors a better understanding of the project context.
- The management of the exchanges (interactions) among the actors: the actor involvement in a design project could be measured by the quantity of exchanges that he has generated.

Our goal is not to suggest here a sociological analysis of organisations. However it appears that the cooperative design is directed by some rules: social, cultural or imposed by the project context. In the case where these rules don’t seem equal for each actor, they will slow down collective cognitive activity, i.e. the coordination: exchanges, interactions.

2.2 The collective cognitive activity

The collective activity between a set of actors generates interactions. The principal goal of these interactions is synchronization. The forms of synchronization used generate coordination activities that can be defined at the beginning of the project (tasks, meeting...) – "*explicit coordination*", or generated during the evolution of the project (mail, fax, discussion...): - "*implicit coordination*". The distribution of these coordination forms (explicit or implicit) in a collective activity depends on the nature of the cooperation between the design actors [DF96] [Vi02] :

- Co-design: in this form of cooperation the designers share a common goal. They bring their own competences to reach this goal together. Implicit coordination is then more present.
- Distributed design: It characterizes a collective design where the tasks are clearly defined and distributed to each actor at the beginning of the design. Each actor tries to reach a goal (or "sub-goal") by participating simultaneously (and not jointly) in the realisation of a final common goal known by every one. It is explicit coordination that is more present.

2.3 Cooperative building design

The legislative setting

Every building operation is composed of three stages: design stage, realisation stage (building construction) and an intermediary phase of enterprise consultation (invitation to tender). The French legislative framework is based on the MOP[1] law. Different stages have been identified to control this design/construction process. Ten engineering missions have been defined according to the different types of operations (new buildings, re-use/modification...).

Coordination model

The coordination model present in the architectural projects is the engineering one [Mi96]. Every project is composed of three actor families associated with a specific function: the owner or contracting authority (MOU), the project manager team (MOE), and the realisation team chosen by the owner or the manager. This coordination model has shown some limits [Mi96]: the distance between the owner and the project manager team, the coordination based on contract, which does not support dynamics in the team, or the lack of knowledge management. The "open" character of the cooperation accentuates these limits. The actors collaborate just for the occasion of the project. At every new project, a new team is defined, in which the architect stays as the central actor.

[1] Mastery of public work law (MOP)

The architect's role
The architect's role within the project is both complex and varied. First, he is the "original creator", the one who expresses the "concept" or the "architectural line" that will guide the design project. He is also the proxy of the project manager team; this role is certainly the least obvious to assume. Thus, the architect must take decisions and arbitrate the conflicts while respecting the constraints of the site and those of his client. He is the principal negotiator in a network where the different actors have not the same level of engagement in the design.

3 A cooperation and context representation model

The design field and more particularly the architectural design field are characterized by a particular context. In this context each component of the project has a specific environment with which it is in relation. For example, an actor has relations with his documents, the activities in which he participates, and the actors also implied in the project. The cooperation model that we suggest here is the representation of the relations existing in a design project. This model definition takes place in the field of the meta-modelling approaches [Fr03] used in MOF standard (Meta Object Facility) proposed by the OMG (Object Management Group). This standard defines four modelling levels: M3 (the MOF), M2 (the meta-model described in MOF), M1 (the application model), and MO (the application).

3.1 Meta-model objective

Our proposition is based on the definition of a relational meta-model of cooperation. This meta-model can represent the relations existing between the elements of a project. Its instantiation allows the definition of cooperation models applied to the AEC field such as the public contracting authority in accordance with French law (MOP law, 1988).

The use of such a structure – suggested by the OMG – permits a better comprehension of our model. We can describe it by distinguishing three concepts: *the generic concepts* (M2), which are common to every design project practice, the concepts *specific to the building field* (M1), and then *their application in a particular project case* (M0) which can be a building project.

The application of this architecture allows us to imagine the definition of links between different tools: process or organisation modelling tools, project management tools and design tools. The MOF principle consists of the normalisation of the exchanges between models, offering projection rules independent of every system. Persistence is saved by the use of a structured language such as XML (Extensible Markup Language). These projection rules are normalised in the XMI specification (Xml Metadata Interchange) [OMG00].

3.2 Principal concepts of the relational cooperation meta-model.

The definition of our meta-model concepts is based on works using a conceptual point of view on the groupware definition [EW94] [SSL95]. These works allowed us to imagine how these fundamental concepts could be reinterpreted in our application domain [Ha02].

The actors
An actor is characterised by his action capacity and his autonomy in decision-making. The actor works, gives his opinion or produces information on the project. He is characterised by his place in the organisation (the company he works for and his hierarchical level) and by his capacities: his specialisation and his own skills. The actor acts inside the activities, which constitute the project, and keeps up relations with the environment while collaborating with other actors and producing documents.

The documents
A document represents a professional "deliverable" part of a contract. For example, the invitation-to-tender document will include plans, spreadsheets and texts. A document is an aggregation of files manipulated through an operating system. A document can embody several other documents. Finally, documents are generated by actors during activities.

The activities
The activities inside a project have several levels of granularity: project, stage, task and request. These activities can have different objectives (coordination, production or synthesis). They can be parts of explicit coordination between actors established before the global activity development or parts of the implicit coordination generated during the activity development.

The relations
A relation identifies a type of link existing between two elements of the model: actor, activity or document. These relations can be grouped into several categories:

- The relations between actors and activities define the role of an actor in an activity (operational role, organisational role).
- The relations between actors and documents are close to those used in the edition: supervise, produce, comment, consult, revise, diffuse.
- The relations between activities and documents are relative to the production of information: generate, use (technical requirements, rules, contracts).
- The relations between actors find their terminology in human resources management: manage, contribute (provide and receive information).
- The relations between documents are those used in the configuration management: new version of, refers to, is the synthesis of, and so on.
- The relations between activities are relative to planning: follows, precedes, is included in, and so on.

Three classes represent the general concepts of our meta-model: actor, activity and documents (Fig. 1). Relations link these concepts.

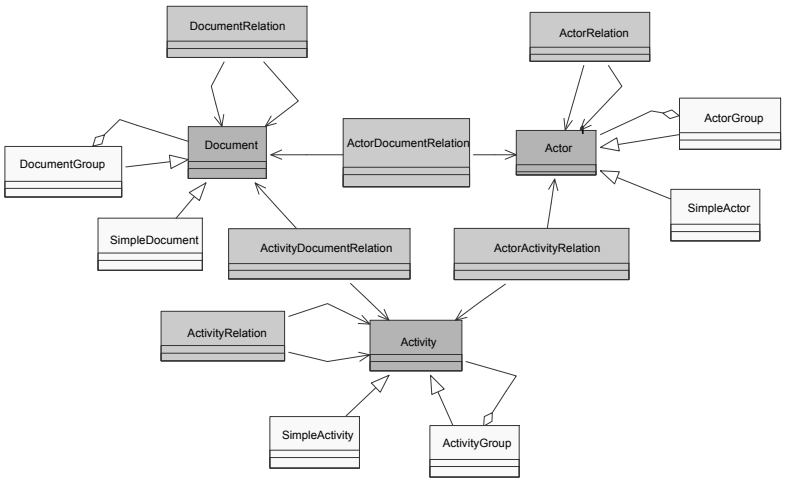

Figure 1: Principal concepts of the cooperation meta-model (extract)

The relation Actor-Activity is the most important one in this model, because it participates in the representation of the role played by an actor in an activity (who can do what?) and of the role, which was played by an actor in an activity (who has done what?). The relation that links actors and activities constitutes a particular case because it determines the other relations. This relation is the role of an actor in an activity.

The role: an Actor-Activity relation

This role can be in two forms: the role given during the planning of the project (regulation) and the role really played that we can analyse during or at the end of the activity. The role translates an actor's implication in an activity [Do99]. This activity could be a project, a project stage or the realisation of a task. It depends on the actor's status in the group (his responsibilities) and on his skills. The role can also be the capacity of an actor to realise actions in an activity. These actions are linked to the possible operations on the elements, which compose the project. In our model, we call this role: "operational role" (Fig. 2).

A second role can be attributed to an actor. It is the role associated with the participants as an organisation. This role, called "organisational role" allows us to define a legal framework for cooperation, which is present in the contracts (engineering team, owner, expert, control organism, administration, …)

The role played by an actor in an activity traces every action made according to the role attributed at the beginning. This Actor-Activity relation allows to answer the question: "who has done what?" and describes the project history.

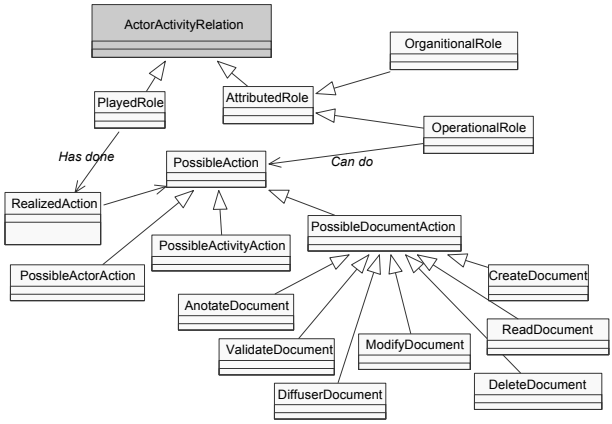

Figure 2: The role of an actor in an activity (extract from the meta-model)

3.3 Application to the architectural design context

The application of the relational cooperation meta-model, the M2 level, to the architectural design has been realized by an instantiation of the different classes of the meta-model (Actor, Activity, Document, Relation). This instantiation, the M1 level, has been obtained according to the MOP law directives. In this first model, we tried to represent the phase of studies with all of the documents, actors and activities, which are present and all the relations they keep up. Figure 3 illustrates the instantiation defining the explicit activities of a project (project, phase, task) and the potential roles (operational and organizational) that can be assigned to an actor in a project.

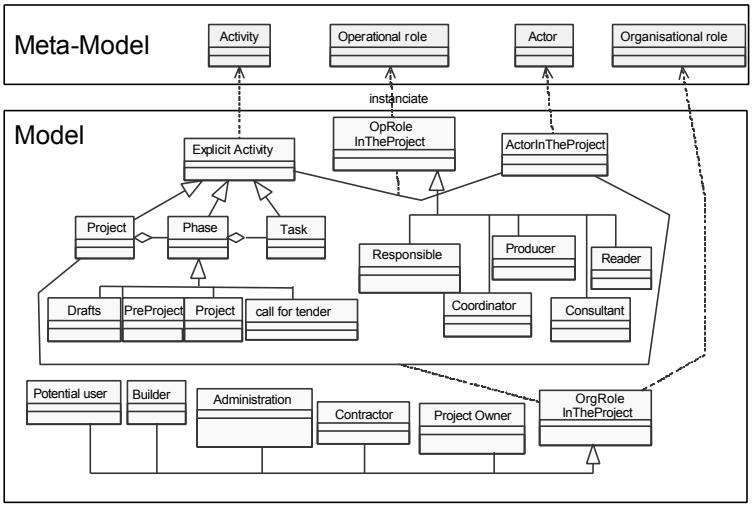

Figure 3: Instantiation of the cooperation meta-model in the architectural design context (MOP law, model extract)

It is this model that has been used for the contextual visualization of a cooperation project based on a hypermedia structure.

4 An alternative visualization of the context

The research in the field of information visualization [HMM00] and adaptive hypermedia [Br01] enables us to identify new forms of information representation, more suitable to our preoccupations.

4.1 the hyperdocument "project"

The flexibility of hypermedia technologies has already been used in the context of a collaborative edition by using shared spaces [St92]. We can also mention the CHIPS project (Cooperative Hypermedia Integrated with Process Support) [WH00] that uses hypermedia to assist a group in the regulation of a workflow. Internet and its distributed hypermedia structure have extended the space of collaboration either in collaborative information management [GK99] or in collaborative project management [In01]. Our contribution is situated at the representation level of a project inside a distributed work group. Our hypothesis is that the more the project representation reflects the relational and social organisation of the real project, the more the vision of the project that is proposed by the system can be suitable and adapted to the users.

The organization of the project and its evolution can be visualized in the form of a hyperdocument described by a meta-model of graph (Fig. 4). Every node in this graph is in correspondence with a class of our meta-model (actor, activity, document) and the links between nodes represent the relations existing in a project (role, Actor/Document relation,...).

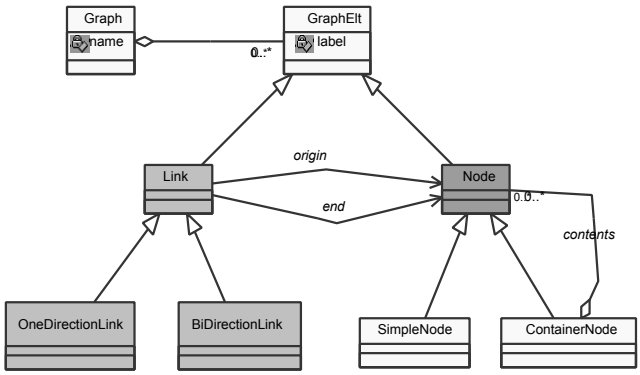

Figure 4 : The meta-model of graph used for the visualization

The use of the MOF architecture for the definition of the two meta-models encouraged the implementation of exchanges between the M0 levels of the proposed architecture (Fig. 5). A MOP law instantiated project will be easily "displayable" by a graph visualization tool based on the graph meta-model concepts.

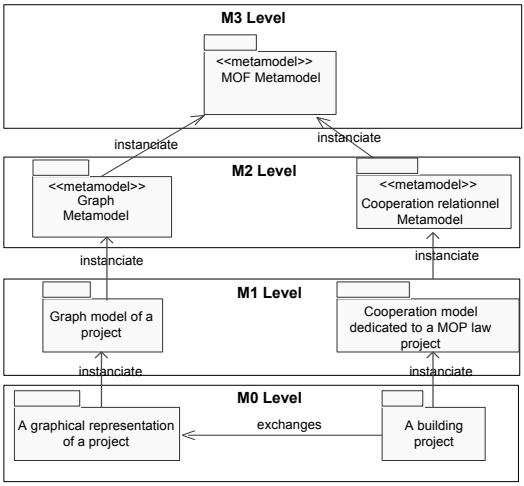

Figure 5 : MOF architecture adopted for the contextual visualization

The instantiation of the cooperation model (M1) dedicated to the MOP law produces a hyperdocument where the nodes are the actors, the activities, the documents and the links represent the relations that exist between all these elements at a specific moment of the project evolution. This hyperdocument represents the cooperation context of a project. The handling of this context representation requires a visualization tool specialized in graph navigation.

4.2 A contextual vision of the project

The visualization of this hyperdocument is obtained by a graph representing the network of the organization of the project in progress (fig. 6).

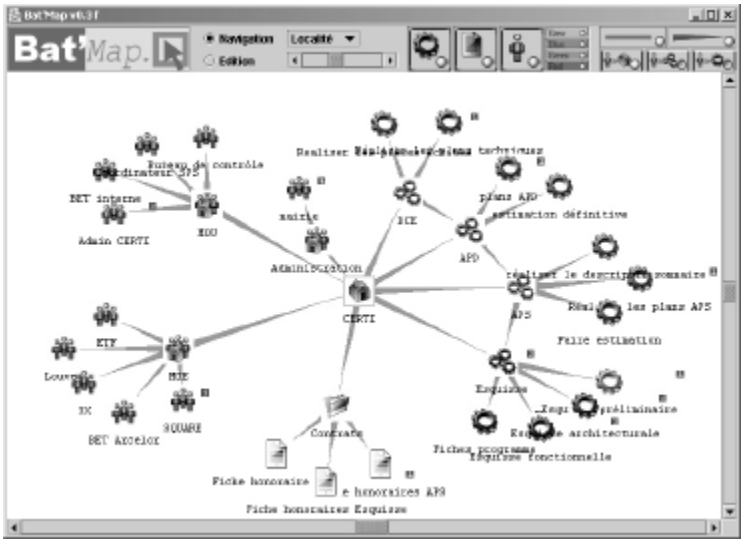

Figure 6: Contextual visualisation of the cooperative project

In this type of representation, the quantity of information and the number of different elements to represent is very important [Be67]. In order to make it less difficult to understand for users, they must be able to discover the complexity of the network gradually. Elements are represented by identifiable forms that colour indicates the state (not started, in progress, terminated) in order to offer an explicit interface.

The form is also used to represent the type of document (norm, plan, contract), actor (group or people) or activity (project, stage, task). The form, the colour and the link length allow us to give information on the type of relations represented (actor's role, reference between two documents, task sequence).

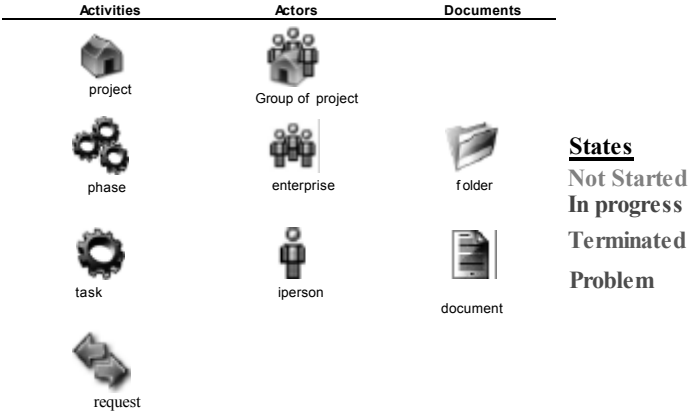

Figure 7: Graphical representation of the project elements.

4.3 Incremental and adaptive navigation in the project.

The navigation tool has functionalities allowing the users to handle the graph. Incremental navigation by progressive deployment or selective masking of nodes or links is possible. Incremental navigation following the hierarchical structure of the information is also usable by deployment or masking of structuring nodes (document/folders, activity/stages, actor/organisation).

The use of filters allows us to visualise the most relevant information in the graph related to a precise context. These filters allow the user to choose the type(s) of information that he wants to see. An example of use of these filters could be the visualisation of the actors participating in a group of activities, without the produced documents, to maintain a comprehensive representation. The role played by each actor in the activities of the project allows the system to define the degree of accuracy of the interface proposed.

For example, a project manager can navigate in the versions of a document while a simple participant will just see the latest version of a document. The adaptive vision allows each user to evaluate the tasks he has to realise in a specific project or in every project he participates in. It defines his potential for action.

5. Conclusion

The cooperation in design defines a particular exchange and interaction context. The meta-modelling techniques allow us to describe a general context of design cooperation and to instantiate it in the particular architectural field. The graphical visualisation that we suggest to represent this context to the designer is based on an instantiate model of navigable graphs. These propositions are based on interoperability principles but are just the beginning of a work on cooperation context representation and visualisation. The major perspectives concern the integration in the model of the design objects, their geometric representations, their technological definitions and their evolution during the cooperative design process. A new cooperation context, oriented to the “digital mock-up” can support these new types of representation in cooperation.

The objective is to define the place and the role of the digital mock-up in the cooperative design context. This reflexion must be based on a study of IFC structure, a standard exchange format dedicated to the construction, in order to suggest a solution interoperable with existing tools.

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