A relational approach of cooperation in building design.

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Abstract

The methods and models of the concurrent engineering taken from the industry domain are unsuitable for the domain of the construction, which is characterized by a singular context of cooperation. The existing groupware tools can not be directly used in the framework of the architectural conception. They require a high level of definition of procedures and exchanges, which is incompatible with the flexibility of current practices. At first, we present the particularity of the context of the building cooperation, then we illustrate through an experiment the problems put by the use of a groupware tool based on a hierarchical data organization. From this experiment, we justify the interest of building a new model of cooperation where the relational organization of the project is taken into account. The integration of this new dimension allows to propose to the user an adapted vision of the project by taking into account the role he plays inside the project.

Keywords

Cooperation model, groupware, cooperative work, project management, architectural project

1 Introduction

The first places where collective practices of production have been developed, with an empirical approach, were the very large building sites of pyramids and cathedrals. A major characteristic of these practices was their surprising flexibility. Their systems of exchange and decisions, which were slightly hierarchized and codified, allowed adaptive managements with a great efficiency [Gimpel 1977]. This ability to match numerous working contexts allowed these systems to exist during several centuries.

The development of industry in Europe during the XIX^{-TH} century introduced a rupture. Using military practices developed in arsenals and royal factories, the industry defined command rules and hierarchical organizations [Bernoux 1990] between professions and men.

We think that this fact of history is the foundation of two paradigms of collective work. The first one is the paradigm of the cooperative exchange where the actors coordinate their activities in an implicit way according to the advancement of the project. The second one is the paradigm of the commanded exchange in which the activity is planned a priori and the coordination among the actors is explicit. They are two forms of collaborative works based on different economies, relations and exchanges.

Today, these two approaches still exist even if the distance between both work models has decreased. We think that an aiding tool for cooperative work in the building domain should propose an explicit coordination (directive) of the project based on an implicit (flexible/free) coordination [Godart, Halin, Bignon, Bouthier, Malcurat, Molli 2001]. The explicit coordination needs to explicit a process and to enforce it. On the other hand, the implicit coordination supposes an auto-coordination between actors, which is based on group awareness techniques. Thus, an architectural design project owns specific phases, which have to be planned thru a process (explicit coordination) and involves also some decision times obtained by negotiation (implicit coordination), which are not often foreseeable.

This paper analyses the concurrent engineering practices in the French building context and proposes an adapted model of cooperation dedicated to heterogeneous and short-lived teams. Our hypothesis is to consider, in such specific context, that a model of collaboration has to take into account the relational organisation of a project and the particularities of each actor. We propose a relational model of cooperation where the information organisation rests on the relational network of the project and which is able to give to each actor an adaptive vision of the project evolution. We show the advantages of this model with regard to the hierarchical organizations usually proposed in the commercial groupware tools.

The next part presents the context of collaboration in an architectural project. The existing models and tools are exposed in the third part. The relational model is explained in the last part.

2 The French building context

Our analysis of the building trade allows us to put in light four categories of factors: the cyclical factors, the contextual factors, the cultural factors, and the structural factors.

The cyclical factors express globally the new economical pressures on the actors, especially nowadays in France:

- ?? an increase of the quality requirements;
- ?? a reduction of the conception and realisation delays;
- ?? an intensification of the competition between actors.

The contextual factors, less connected to the current events than the previous, define the place of the sector in its legislative context:

- ?? the institutional context plays a very great role. In France for example, law on procurement contracts forbids the grouping of project managers with building firms;
- ?? the variety of contracts binding actors ;
- ?? there is no possibility of scale economy ; the notion of “range of products” is exceptionally present. Any re-use is difficult.

The cultural factors highlight for instance, the specific value system or the educational standards of the actors:

- ?? the financial, methodological, conceptual independence of companies ;
- ?? the very empirical exchange manners of information where the oral expression plays an important role (e.g. commitment on word, the implicit communication, the direct contact);
- ?? most small firms experience difficulties mastering the most elementary computing.

The structural factors define the relationship between actors during their collaborative activities:

- ?? the numerous small companies;
- ?? the teams are recomposed in every project. The changing nature of relations prevents the establishment of any universal valid protocols between actors.

Two coexisting organisational modes appears from the analysis of these factors:

- ?? a hierarchical mode, derived from the structure of engaged companies, such as the relation between a boss and his employee,
- ?? a network mode, derived from the necessity of these independent companies to co-ordinate their interventions and to take over from the hierarchical mode in the numerous situations where this one turns out ineffective or inapplicable.

By convenience, we entitle “project-company” this hybrid organisational mode. The short-lived, decentralised and fluctuating characteristics of “project-company”, seems to us typical of the building sector, and make it different the branch of industry.

3 Existing models and tools

With a few exceptions, the concurrent engineering tools taken from industry and services are not used in building projects. We make the assumption that the lack of use of these tools is due to their non-fitting to the specificity of the building sector. The common tools can be classified in four types [GRU 94]:

- ?? Tools based on electronic mail,
- ?? Groupware tools,
- ?? Workflow management systems,
- ?? Electronic drawing management systems,

These tools try to transpose in computer terms existing situations and use frequently some hierarchical rules to organize information. Then, a data hierarchical model is used by most of the current groupware tools, dedicated or not in the building trade [Bentley, Horstmann, Trevor, 1995], (BSCW, Teamwave, Buzzsaw, Batibox, …).

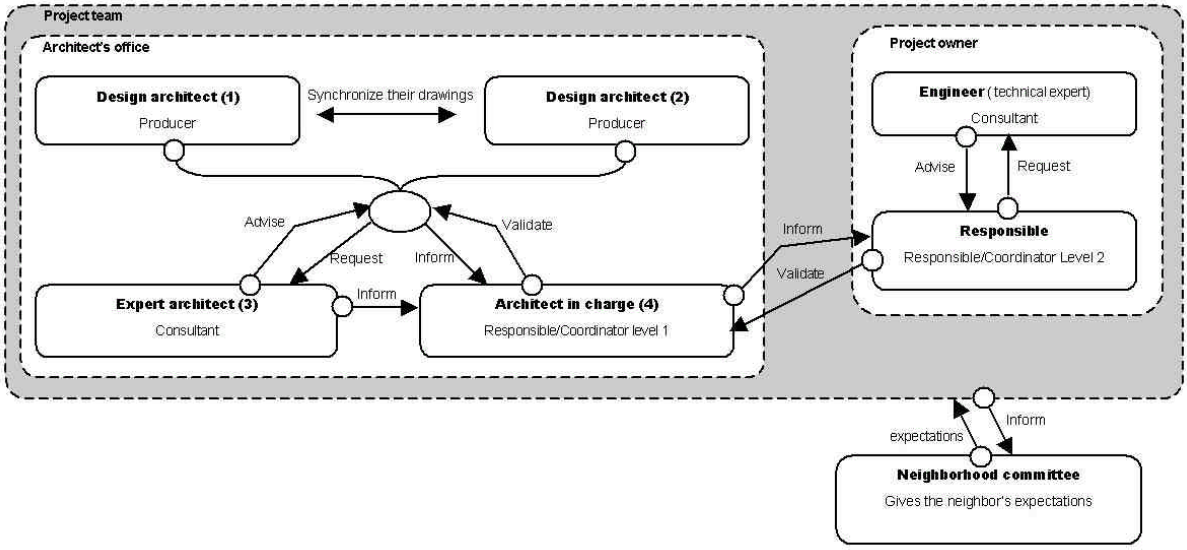

Figure 1: Actors’ roles during the preliminary design process activity

In order to show the lacks of this kind of systems, we studied a groupware tool used during the conception of an urban planning project [Hanser, Halin, Bignon 2001]. This case study showed us the relations and the roles held by the actors during the preliminary design activity of a project. The actors during this activity manipulate documents to produce drawings, texts and spread-sheets and interact with other project participants. To produce these documents, actors have to take a role inside this activity (cf. Figure 1).

We can remark that this activity had two level of validation (internal and external) on the document production. In this case the actors (and their role) are: two design architects (producer), expert architect (consultant), architect in charge (responsible level 1), technical expert (consultant level 2), member of project owner (town council, responsible level 2), and neighbourhood committee member (Reader).

The organization of project information is expressed through a system of files and folders (cf. Figure 2). To preserve a meaning outside the system, the name of a document should reflect its position in the system. Thus, the use of these tools is based on rules of naming files and graphic

charters. These rules are difficult to hold in place during the realization of the project. The more the number of users and documents increases, the more it is difficult to apply the existing system of naming, storing and browsing because the hierarchical structure management coerces the actors to generate many file copies. The figure 2 show an example of document validation sequence during the project progress with the use of a classical groupware.

Therefore, these tools couldn't respect the strong autonomy, which characterized the actors who collaborate during a building project.

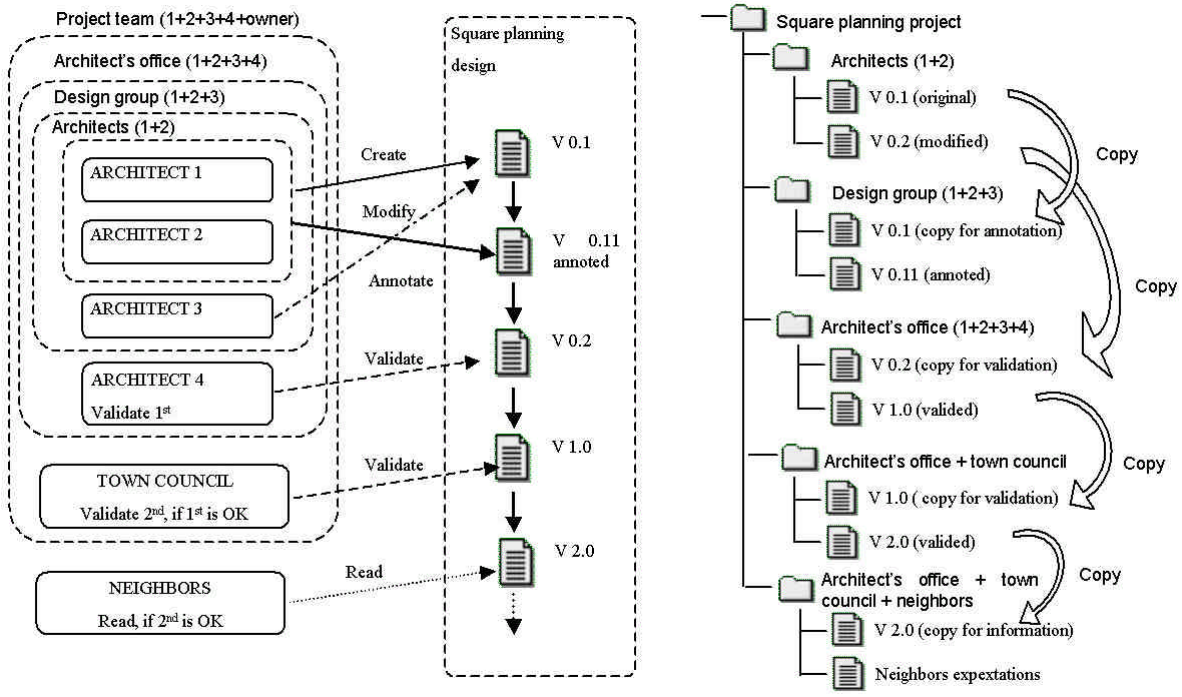

Figure 2: A document validation sequence with a classical groupware

The available cooperation models used in these existing tools do not allow to represent the relational network that exists and evolves between actors during the project lifetime (cf. Figure 1). These models, based on a hierarchical representation of information, force the project organisation to have either a document oriented structure (cf. Figure 2), or an activity oriented structure, or an actor oriented structure, but never the three structures together.

4 Relational model of cooperation

As we shown, the building trade represents a particular context of cooperation. This cooperation results in hierarchical and cooperative interactions between actors. The exchanges between actors respect of course a hierarchy, but imply all the actors in the design of the final object. This situation is characterized by a "mutual prescription" [Hatchuel 1996] between designers. Thus, each component of the project owns an environment with specific relationships. For example, an actor keeps up relations with its related documents, with the activities it takes part and the others actors who participate to the same activities. The 'relational model' will be the representation and the characterization of these interactions in an architectural project.

4.1 Main concepts

The definition of the model concepts carries on with those included in the works about groupware conceptualisation [Ellis, Wainer 1994], [Salvador, Scholtz, Larson 1995] and [Cisse, Ndiaye, Link-Pezet 1996]. These definitions will help us to understand how to use these common concepts in a new representation of the collaboration in a project.

4.1.1 Actors

In a project, each actor owns a limited capacity of action and a restricted decision-making autonomy. An actor is characterized by his company, his hierarchical level, but also by its own range of competences. For example, an architect can not be only defined by his profession because he may have one or more specialities in a particular construction technique (wood, metal, or concrete) or have an experiment in some software tools. These data related to actors' competences allows to clarify and to orient the role attribution inside the project and the possibilities of action resulting from this.

The actor acts inside the activities constituting the project, gives his opinion, keeps up relations with his environment while collaborating with other actors and producing documents.

4.1.2 Documents

A document represents a professional "deliverable" piece, the sets of parts relative to a particular point of a contract. For example, the invitation to tender document will include plans, spreadsheets and texts. A document is an aggregation of files manipulated with an operating system. A document can group several other documents. Lastly, documents are generated by actors during activities.

4.1.3 Activities

The activities inside a project have several levels of granularity: project, stage, milestone, and task. The French law about building project management defines legal stages of a project and the corresponding levels of drawing scale. The milestones separate two validation meetings inside a phase and the tasks constitute the smallest element of an activity [AFITEP 1991]. We can isolate four activity categories:

- ?? Explicit coordination activities: actors management and tasks management,
- ?? Implicit coordination activities: request management,
- ?? Production activities: document creation and revision,
- ?? Synthesis activities: document validation or merging.

Implicit coordination is done mainly by sending requests between actors. They can be associated with documents and make it possible to give specific signification to exchanges [Malcurat, Bignon, Halin 2000]. The requests that we consider in our model are as follows:

- ?? For information,
- ?? For consultation,
- ?? For advise,
- ?? For modification,
- ?? For validation.

Requests can also be generated by as a reminder software to inform the actors.

We can notice that these fundamental concepts maintain reciprocal links we have generalized under the concept of "relation", which enables us to define the "relational triangle" (cf. Figure 3).

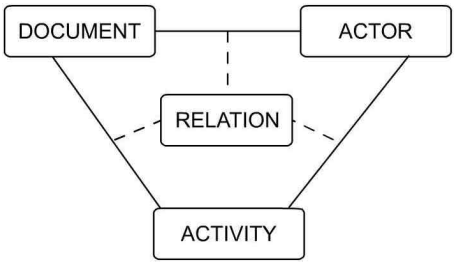

Figure 3: The relational triangle

4.2 The transversal concepts

These concepts precise the semantic of the model by giving more information about the main concepts.

4.2.1 Relation

A relation identifies a type of link existing between two elements of the model: Actor, Activity and Document. These relations can be group in categories:

- ?? The relations between actors and activities are closely dependent on the role of an actor in an activity (responsible, producing).
- ?? The relations between actors and documents are close to those used in the edition: Supervise, Produce, Comments, Consults, Revise, Diffuse.
- ?? The relations between activities and documents are relative to the production of information: Generate, Uses (technical requirements, Rules, Contracts).
- ?? The relations between actors find their terminology in the human resources management: Manage, Contribute (provides and receives information).
- ?? The relations between documents are those used in the configurations management: new version, refers to, is the synthesis of etc....
- ?? The relations between activities are relative to planning: follows, precedes, is included in etc.....

The relation that links actor and activity constitutes a particular case, because it is a condition for determination of the other relations. This relation represents the role of an actor in an activity.

4.2.2 Actor-activity relation, the actor's role

Each actor has a specific role in the project; this role is defined according to the contracts signed between actors. Responsibilities can be assumed by turns by several actors during the life of the project (according to their reciprocal expertises). For example during the draft design, the responsibility will be given to a 'creative designer', whereas for the building site it will be given to a more pragmatic actor like an engineer. The roles translate the implication of an actor in a project [Hanser, Halin, Bignon 2001], it depends on the actor's status in the group (its responsibilities) and on its competences. The roles which an actor can held are:

- ?? Responsible (validate)
- ?? Coordinator (attributes tasks)
- ?? Producer (create information)
- ?? Consultant (answer to a specific need)
- ?? Reader (spectator)

The role makes possible the definition of the place occupied by each actor in an activity, it indicates his importance, and it induces the types of relations an actor can keeps up with other participants and documents. The role of an actor in the project will be a combination of these unit roles, a "consultant" in an activity can become "coordinator" of another activity of the project.

4.2.3 Actions

The actions are deduced from the relations and describe the interventions an actor can carry out on the other actors, the activities and the documents. The relations make possible to define what we name the "action rights " rather than the "access rights" which are so difficult to configure in the existing groupwares. These actions are connected to the operations defined on the principal components of the model (cf. Figure 4). For example, the role of coordinator gives the following action rights:

?? To plan a meeting (activity)

?? To assign tasks to other actors (actor)

?? To define objectives and deadlines (activity)

?? To add or remove actors (activity)

?? To define the documents to be produced (document).

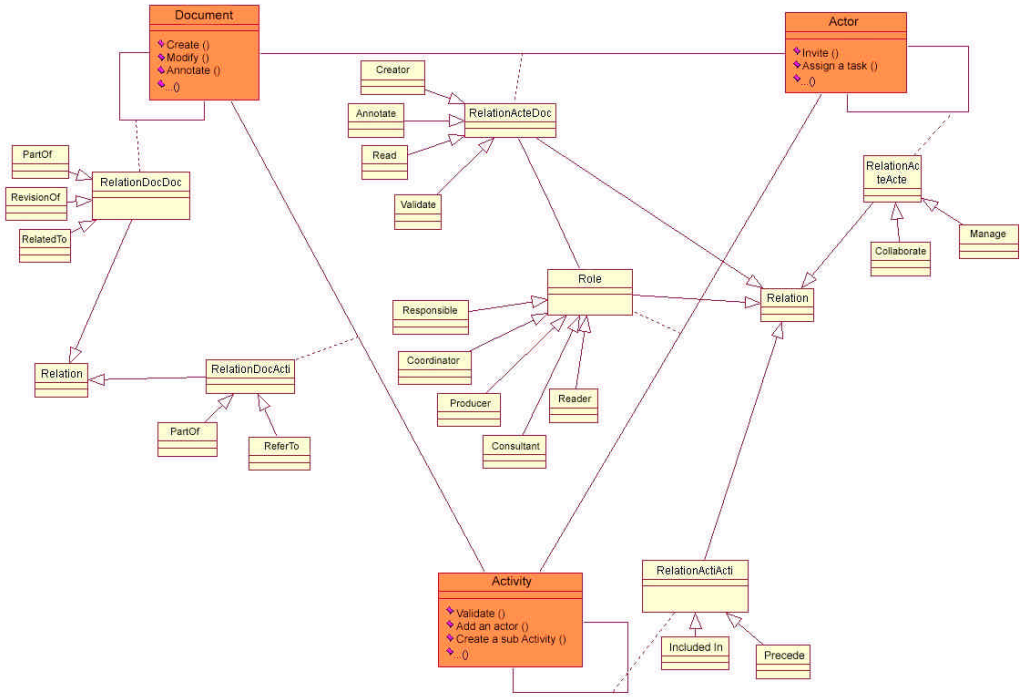

Figure 4 : The relational model of cooperation (designed with UML)

4.3 Project vision

The search on information visualization [Herman, Malançon, Marshall 2000] and on adaptive hypermedia [Brusilovsky 1996] enables us to identify new ways of user information presentation, more suitable to our cooperation model. These modes of user's presentation make possible to show the links existing between actors, documents and activities in the form of a graph of nodes (actors , documents and activities) and links representing the roles and relations.

The information we have to display are a translation of real and virtual items like actors or tasks and their relations. To perform this representation we choose to use a context-adaptive hyperdocument. In our context, the links express the relations existing between the project elements and the nodes are actors, activities and documents. We introduce some different types of links, which express the relations we have shown in the previous part.

To be user adaptive, the hyperdocument have to be different according to the user role inside the project. The role played by each user allows to active the information (nodes and links) to display. For example, an administrator may not have the same vision of the project than a simple reader. For the navigation, we choose to present, with three views, the three main concepts we isolate as points of view on the project evolution: actor view, document view and activity view. The user can switch between these views by clicking on an specific item and make a focus on it (actor, document, or activity) or by choosing the corresponding view.

To show the structure of this hyperdocument, we have to draw a graph of links and nodes. The result is a fish-eye view [Furnas 1986] of the relations in a project.

Some tools according to this logic start to appear (Thinkmap, TheBrain, Touchgraph), we are currently looking for adapted one of these by defining specific types of links and by organizing the various categories of nodes in the interface.

5 Conclusion

The contribution of our research in the practices of concurrent engineering is mainly the proposition of a relational model of cooperation based on a new organization of information closer to the real building context and gives a new dimension to the groupware tools. The relations we identify allow an adaptive navigation inside the project represented by a hyperdocument. The adaptive character of such navigation is obtained from roles and relations of each actor. Roles and relations are determined from the actors' specificities, which evolve along the project life cycle. Thus, the user's presentation of the project progresses at the same time than the real interactions between actors involved in the project. Our work is still under development and the concepts stated in this article are currently implemented in an experimental tool. A realistic validation of our proposal can only be done by one experiment on a real project. This project will implicate some architects, engineers and project owners in a building process. The results of this experiment will be available in a few months because of the project schedule. The goal of this model is to reinforce the co-operation and the group awareness by supplying to the actors a good vision of the project evolution in order to increase the conception quality.

6 References

Association Française des Ingénieurs Techniciens d'Estimation de Planification et de Projet :Le management de projet, Paris, AFNOR, 1991.

Bentley, R. Horstmann, T. and Trevor, J: The world wide web as enabling technology for CSCW : The case of BSCW. In proceedings of the 4th international World Wide Web Conference, O'Reilly & Associates, Boston, pp. 63-74, 1995.

Bernoux, P. (3rd ed.): La sociologie des organisations, Seuil (Points), Paris1990.

Brusilovsky P., Methods and Techniques of adaptive hypermedia, User modelling and User-Adapted Interaction, volume 6, n°2-3, 1996, pp. 87-129.

Cisse A., Ndiaye S., Link-Pezet J. Process Oriented Cooperative Work: An Emergent Framework. Proceedings of the IEEE Symposium and Workshop on Engineering of Computer Based Systems 1996.

Ellis C., Wainer J., A conceptual Model of Groupware, CSCW'94 Conference on Computer Supported Cooperative Work, ACM 1994, pp. 79-88.

Furnas G.W., Generalized fisheye views, CHI'86 Conference, Boston, April 1986, pp 16-23.

Gimpel, J.: The Medieval Machine : The Industrial Revolution of the Middle Ages, Penguin, USA. 1977.

Godart, C.; Halin, G.; Bignon, . J.C.; Bouthier, C.; Malcurat O.; Molli P.: Implicit or Explicit Coordination of Virtual Teams in Building Design. CAADRIA 2001 (Computer-Aided Architectural Design Research in Asia), Sydney, Australia, pp 429-434, 2001.

Grudin J: CSCW: History and Focus; IEEE Computer, Vol.27, No. 5, May 1994

Hanser D., Halin G., Bignon J.C., Relation Based groupware for heterogeneous design teams. Proceedings of the conference Education in Computer Aided Architectural Design in Europe. Helsinki 2001. pp. 86-91.

Hatchuel A., Coopération et conception collective. Variétés et crises des rapports de prescription, Toulouse, Octares, 1996.

Herman, I. Malançon, G. and Marshall, S Graph Visualization and Navigation in Information Visualization : a Survey, IEEE Transactions on Visualization and Computer Graphics, Volume 6. 2000.

Malcurat O., Bignon JC., Halin G., Improving collaboration in Small Scale Projects. Proceedings of the 8th International Conference on Computing in Civil & Building Engineering, Volume1, pp. 488-495.

Salvador, T. Scholtz, J. and Larson, J.: 1995, The Denver Model for Groupware Design, SIGCHI Bulletin, Vol. 28, pp 52-58.