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Towards a flexible IT-based system for process steering in architecture design

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Abstract:
This paper tackles the problem of assisting the steering distributed design processes in architecture. It suggests a macro model oriented steering, based on breakpoints notion borrowed from computer field. We formalize the use of breakpoint into process based on two notions: Concern Situation and Aimed Situation. A first software implementation is tried starting from this modelling.

1. INTRODUCTION

Coordination of the actors and integration of their various points of view still remain a key issue in design processes, and most of the time the origin of major failings. Gathering the various skills and expertise in design in architecture and getting them work together while at the same time preserving a comprehensive and synthetic vision of the overall construction design process, do require to orchestrate a certain degree of coherency while keeping the diversity of ability and competencies. This paper advocates that putting in place formal management procedures for design in architecture has the power to deeply contribute to the anticipated administration of controlled interactions between actors, to the mastering of knowledge and expertise of various business processes, to the cooperation of actors, and can greatly help to support decision making and constructive trade-offs between the various construction players.

To achieve such an ambition, we indeed consider two levels of management in architecture design:

- **The management of design processes,** which requires the identification of pilots whose role is the *cognitive synchronisation* in design process. This level of management allows all the actors involved in this design process to get a knowledge of the states and aims of process that form the design activity;
- **The management of the design project,** which follows the usual rules of project management, and is based on a *synchronisation of time and space* (task allocation, articulation of actions, their workflow, etc.).

Also, depending on the different cost and quality constraints, numerous tools exist in order to "instrument" project management (e.g. Gantt Diagram, project management portals, Computer Supported Cooperative Work, etc.). However, there are no tools that would assist the design processes pilot to assure the coherence and the cohabitation carried by the different actors of the process. For this reason, we focus in this paper on first-level management (design processes management) by proposing a **flexible IT-based system for process steering in architecture.**

The paper is organized as follows.

- In section 2, we present different characteristics of design activity steering.
- In section 3, we propose a macro model of design processes steering that is based on aforementioned characteristics and that refers to the notion of computer debugger (breakpoints). That allows us to introduce two concepts linked to design steering in architecture (*the concern situation* and *the aimed situation*).
- In section 4, we present a first approach of instrumentation of design processes steering in architecture.

2. THE STEERING OF ARCHITECTURE DESIGN

2.1. A CROSS-FIELD ACTIVITY

The steering of a design project in architecture consists in conducting the set of activities and processes that are necessary for the implementation and achievement of the building. Observation of practices showed us that both the building to design and the design process are concerned by this activity. Four main skill-related challenges are identified:

- Maintain the coherence of the building throughout its evolution (coherence between the building and the need for conception, coherence between the different components of the building).
- Take decisions that aim to orient the process and validate the evolutions of the building.
- Integrate the points of view of the different actors. This is completed on one hand by analyzing how the specific knowledge of each actor contributes to the global vision of the building, and on the other hand by translating the different points of view into specifications for the building.
- Organize the cooperation by managing the network of actors and skills in the light of the objectives and by keeping the convergence in the definition of the solution.

The different tasks delivered by the steering activity are therefore interdependent and complementary. Moreover, as the nature and origin of a project influence the steering activity, the project can bring an answer to many unfolding schemes that imply a different steering approach. This is why the design of steering generally depends on the know how and personal experience of an actor.

In order to steer effectively, this actor tackles each event, new solution, and new task through all the implications they can have in all the fields of the project. Therefore, the steering of design appears narrowly linked to the evolution of the design process.

In that way, numerous actors come up with answers in order to effectively steer the design processes in architecture. They propose to “distribute activity in *an intelligent manner*, to the *right actor,* in order to reach the *most systematic possible* level of integration of his solution.”

2.2. A PREDICTIVE AND REACTIVE ACTIVITY

The design process is often too complex to be entirely conducted in an intuitive manner, without being structured beforehand. A clear framework that imposes to the actor of design a certain “line of conduct” is necessary in order to run the process effectively. However, in order to be effective in the design process, actors need some degree of freedom. They also need to be able to define their own business processes and adapt them to the needs of projects and to the evolution of practices. We consider here the two aspects of a given process. Design is a predictive activity, that has to be planned and instrumented. It is an activity for which actions that will be implemented are defined beforehand. At the same time, design is a reactive activity, that evolves and adapts as its content changes with the environment and with the personality of the actors that conduct it. All the complexity of the design therefore lies in this duality.

It is therefore agreed upon that design steering consists of organizing and planning tasks with already identified mecanisms and results. It also consists in managing events, actions and situations that are not initially known and formalized. The success or failure of a project is often explained by the manner in which these different unplanned situations are managed and controlled.

3. MODELLING DESIGN PROCESSES IN ARCHITECTURE

3.1. THE MULTIDIMENSIONAL ASPECT OF DESIGN PROCESS IN ARCHITECTURE: A BARRIER TO A FULL MODELLING

During last century, numerous approaches were created in order to modelling design process in architecture.

Many researchers such as Pena (Peña 1977) and Alexander (Alexander 1971) consider this process as a sequence of problem solving situations that can be treated in different ways in order to be resolved in a satisfying manner.

Taking into consideration the nature of the problems to solve and the degree of their complexity, Raynaud (Raynaud, 2002) highlights that the architect faces two types of distinct situations: “a problem solving situation with non defined actions” and another one that is “directed by multiple goals.”

Indeed, the actors of design faces difficulties that sometimes require to use scientific rules in order to formulate or reformulate the wording of the problem using logical processes. In spite of that, this detection is not considered at all as a final solution. It is an unfinished process and not a closed and finite system (Prost and al, 1995). Moreover, the actors of design often face problems of multidisciplinary nature and firmly embedded, that need multiple satisfying proposal. In an architectural space, one element can serve multiple goals of structural, functional, architectural, and even urbanistic order.

Moreover, design processes are not linear but dynamic, and the upcoming solution is the result of an « iterative » approach.

In this sense, we come close to the conclusions of Schön (Schon 1983) and Visser (Visser 2002), who give to the problem and its construction a capital importance. Hence, the design process is, from a macroscopic point of view, the transition from a problematic situation to an objective one therefore leading to the solving of the problem. This implies, from a finer point of view, the alternative implementation of problem-solving and problem- setting activities. Nidamarthi (Nidamarthi 1997) comes up with the same conclusion through a descriptive study of activities conducted independently by two designers working alone on an identical given problem. He distinguishes problem-solving activities from problem-setting ones. He notices that these activities are conducted throughout the design process. He concludes that there are not necessarily preliminary to the other design activities.

The representation of the problem then evolves throughout the long design process. In addition to the two dimensions of time (or phases) and their related tasks, the dimension that distinguishes the statement of the problem from the definition of the solutions should also be considered. Moreover, we can assimilate the tasks to the different professions to which it is associated. This choice allows to represent the problem-wording and problem-solving processes in a three-dimensional space (see Figure 1).

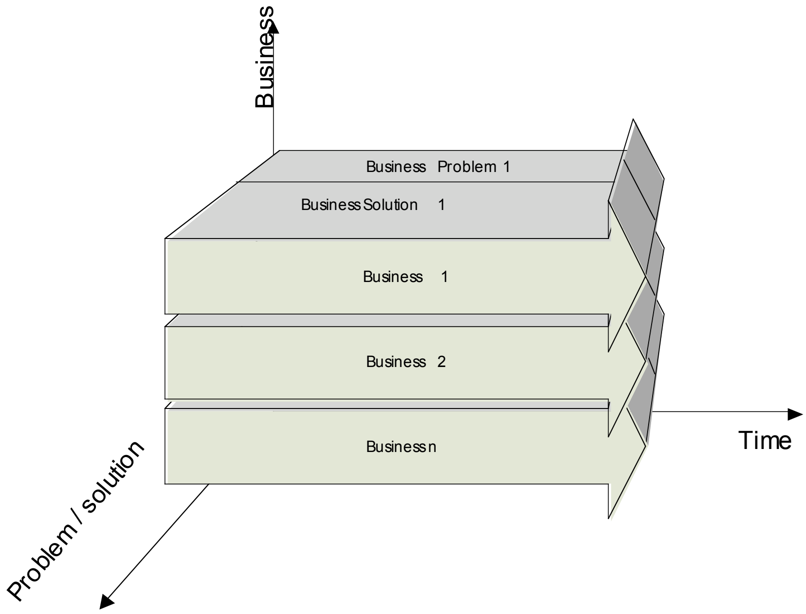

Figure 1 : The multidimensional aspect of design processes

Through this multidimensional aspect of the design processes, we enhance the lack of a model that allows to fully explain design in architecture. Consequently, it becomes necessary to concentrate on the steering activity of the design in order to build a modelization of the design processes in architecture that is steering-oriented.

3.2. A STEERING-DRIVEN MACRO MODEL OF DISTRIBUTED DESIGN PROCESSES IN ARCHITECTURE

Design in architecture is characterized by uncertainty and the lack of formalized specifications. Because design objectives are continually re-evaluated (Simon 1992), it doesn't allow to define unique processes.

Moreover, as described by (Darses & Falzon 1996), (Turk et al 1997), (Hanser 2003) the implication of actors in a design process can take various forms. Their engagement in the process is similar to a Co-design or a distributed design (Figure 2). The actors can meet these two situations successively, during the same project or the same design process.

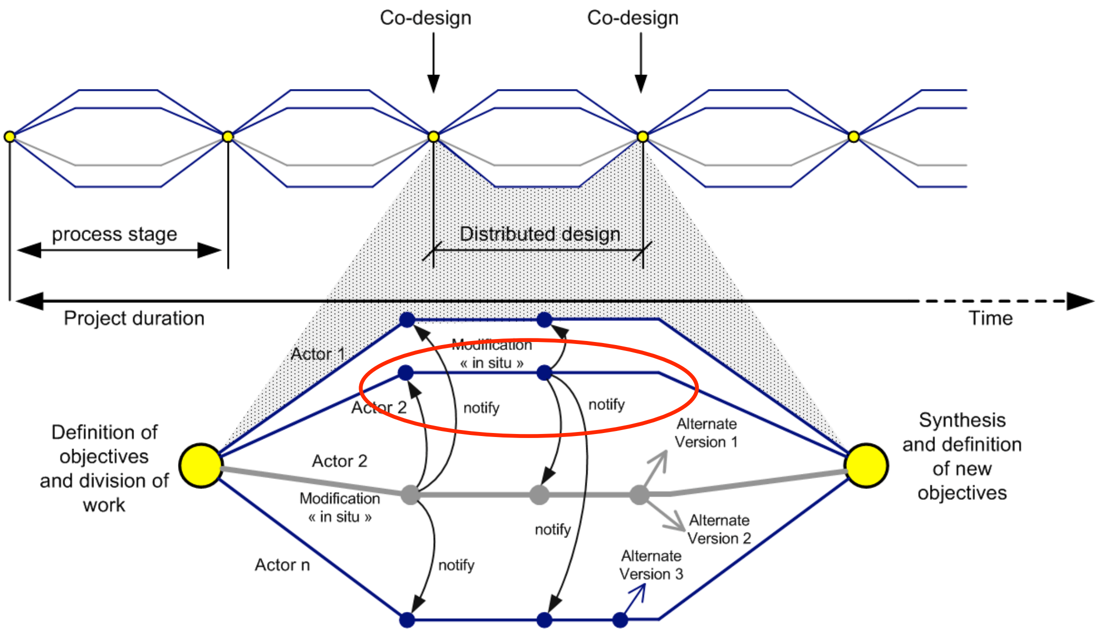

Figure 2: Distributed design and points of synthesis. Hanser, (2003) according to (Turk et Al. 1997)

The questions to which we aim to bring answers in this article concern the specific needs necessary for:

- ensuring the steering and coordination task of the distributed design processes
- ensuring a coherence between all the proposed solutions that are generated by the integration of the points of view.

In order to satisfy these needs we propose to modelize the distributed processes on the basis of activities already identified. This whole set of activities serves as a common core for all the observed design projects. In fact, we find these activities in the intervention of each actor of design either explicitely or implicitely. These activities can be classified in three types: analysis, proposition and evaluation.

- **Analysis:** it includes all the activities of collection of technical, regulatory, economic, administrative data (e.g. regulatory constraints analysis, analysis of the documents of another actor, etc.)
- **Proposition:** it includes all the tasks that allow to implement ideas or generate concepts (proposition of an insertion in the site, volumetry proposition, proposition of a principle of structure, etc.). These tasks are realized through production tasks and require coordination tasks when carried out by mutliple actors. They list, in a recursive manner, the types of possible responses to the problems encountered. This listing is achieved in the form of options and hypotheses, from their suggestion to their formulation. Organisation plans and figures as well as spatial development propositions are produced by taking into consideration specifications from previous phases. They hence have to reflect the relevant options and be coherent with the criteria of functional and spatial organisation of the project in question.
- **Evaluation of the proposition:** it includes both personal and collective assessment of proposition.

The content and the scheduling of these activities are different following the type of design. We therefore propose to modelize distributed processes of design in architecture in the form of a macro process which progression is sequential and iterative (figure 3).

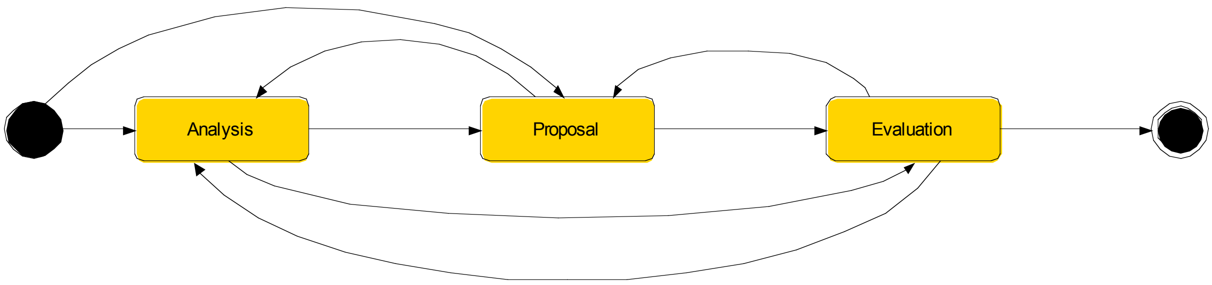

Figure 3: a macro model of distributed design processes in architecture

Independently on his entry point in the distributed processes macro model, an actor has the possibility to undergo the three phases in any order and as long as it is necessary. In this manner, an architect, for instance, can initiate architectural design by directly making a technical proposition (for example a volumetry and envelope proposition) intuitively before analyzing the program and the site and then go through the evaluation phase.

This model represents **the predictive part of the steering activity**.

Nevertheless, in practice, what allows the pilots to prevent dysfunctions remains their ability to react quickly and their global and transversal vision of design.
In order to allow the pilot to monitor the right development of the distributed processes of every actor involved in the design, we introduce the notion of debugging inspired from computer science. Debugging is the process through which dysfunctions (bugs) are detected, localized and corrected. Applying it to design in architecture, we propose to base this notion of debugging on breakpoints in order to suspend processes or to inform the pilot when problems occur. These breakpoints represent the place and moment where every actor of the process can send an inquiry to the pilot in order to trigger reactions to unexpected situations. These reactions to the unexpected situations can considerably modify the building to design or hamper the good development of design processes. They also represent the **reactive part of the steering activity.**

In figure 4 herebelow, the breakpoints (red dots) are positioned on the transition among activities. They aim to detect problems before committing oneself in the following activity.

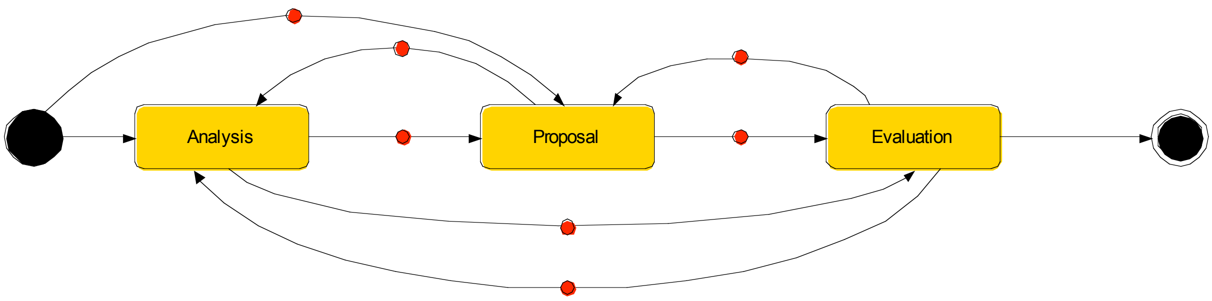

Figure 4: a macro model of design processes steering in architecture

In order to formalize the concept of breakpoints, we associate it to two concepts that are narrowly linked, generally implied, and omnipresent in design projects: the **concern situation** and **the aimed situation**.

- **The concern situation** can be defined as a configuration of a project, at a given time, that does not allow a continuous and effective progression towards the definition of the building to design. It is an obstacle to the progress of the project. It can also be considered as a set of correlated parameters and facts that lead actors of design to situations they did not imagine or anticipate. Regular, pre-established processes are usually unadapted to these situations. In practice, encountered situations are considered as problematic/concern situations only when they involve several fields of the project. In the opposite case, these situations will be treated locally and will not trigger any specific treatment. In order to be identified as a concern situation and be treated consequently, a given situation has to be declared at the pilot's level who measures its importance and decides to launch or not the problem-solving process. Through our analysis of some design projects, we have identified situations that led to the triggering of concern situations. Some of them are the lack of information, the unfeasability of the study, the non-respect of regulatory constraints, the non-respect of specifications, incoherences between the propositions submitted by different actors, and incoherences between the artefacts produced by different actors.
- **The aimed situation** is a configuration of the project that eliminates the concern situation when reached. It also consists of heading towards the definition or the reformulation of the problem. In this manner, the actors of design explicitely define which aspects of the project or building will be concerned by this modification of the project configuration. It also allows them to identify in which fields they can operate in order to reach the new configuration of the project. This work is comprised in a project steering activity and therefore directly concerns the steering team. One particularity of the aimed situation is that it includes a definition of the objective to reach as well as a description of the method used to achieve it. In fact, the aimed situation is built and stated in a way that allows it to be . It describes the configuration that the project intends to reach but also the means to achieve it. It can be described on one hand as the construction of an identified problem that needs to be solved and on the other hand as the expression of a solution for the encountered concern situation.

Based on these two concepts, we can synthesize the content and the principle of use of the breakpoints by the following process (figure 5).

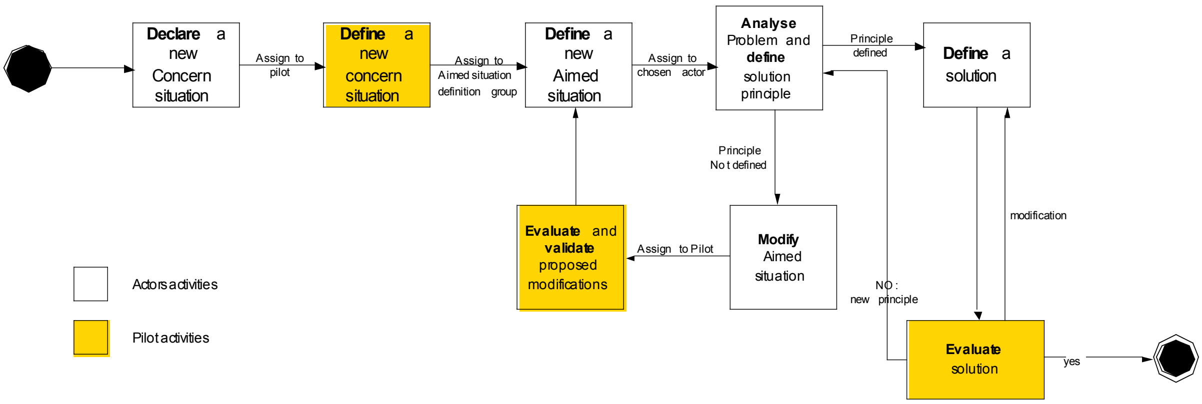

Figure 5: Process of the principle of use of the breakpoints

In this process the pilot's role is to lead all the distributed activities in order to make the project feasible. In a way, his/here role can be itemized in 4 points:

- To support current states and design evolution: the pilot provides the control and the lead of the design, towards the evolution of the solution, in order to maintain coherence in the building under design.
- To integrate the actors' points of view: the pilot provides with a double translation. A translation of the actor knowledge in order to make it available and exploitable in the project, and a physical translation of its objectives and its constraints on the building under design.
- To set up cooperation: the pilot directs the activity of each actor in order to lead them to converge towards common waitings. It aims to set up a "concurrent" definition of a single building in order to answer each actor expectations.
- To come up with a decision by taking into account project constraints and surroundings. These decisions are taken during action, and are closely related to the evolutions of the building and the configuration of the process. These decisions remain hard to schedule according to a well defined roadmap.

With this intention we propose to develop an assistance tool for design process steering based on our macro model of design process steering.

4. INSTRUMENTATION OF STEERING DISTRIBUTED DESIGN PROCESSES IN ARCHITECTURE

4.1. DESCRIPTION OF THE PRINCIPLES

What makes the modelization practical is the fact that it allows to determine the principles necessary to the steering of distributed design processes.

The principles selected to assist the steering of design processes are under implementation in a software application that bears the concepts of the proposed model.

- *Principle 1* : effective steering requires to define the relevant problem (to solve) and state it in an adequate fashion. In order to achieve this, a file that structures the definition of a concern situation helps formalizing the consequences of the problem that threatens the design in progress. It also allows to estimate the risks that these consequences make the project face. The pilot therefore has a relevant basis of analysis in order to decide which problems are relevant for solving and how they will be solved (by phone, in meeting session, according to a given procedure, etc.) (figure 6). A file describing the aimed situation then allows to clearly state the problem by requiring a definition of the objectives and the implementation framework necessary to achieve them (figure7).
- *Principle 2* : the evaluation of solutions relies on an evaluation file that allows negociation between the pilot and the concerned actor. This makes it possible to suggest modifications and validate them (Figure 8).
- *Principle 3*: being informed of the progress of the design project requires the follow up of the status of the distributed processes. A dashboard allows the pilot to monitor the evolution of work and to remain informed about the concern situations. He therefore monitors on one hand which situations have been solved, are in process of being solved, or have been dropped and on the other hand the progress status of the solving of aimed situations.

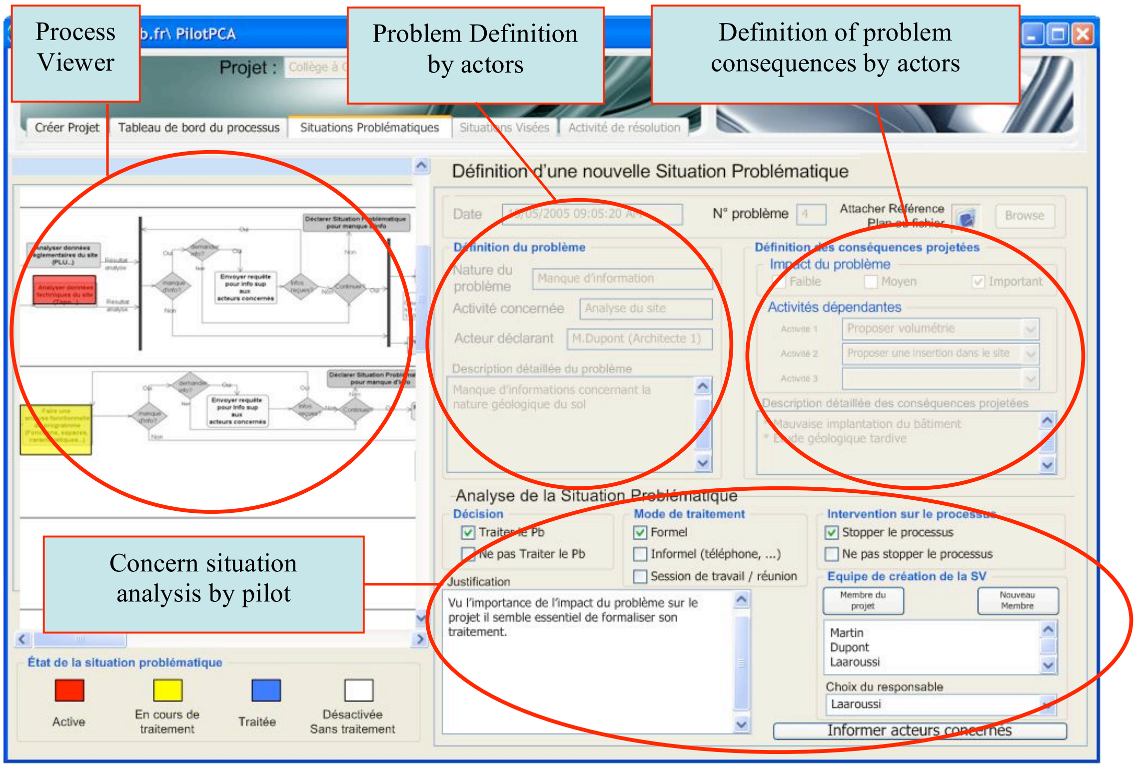

Figure 6 : Concern situation analysis screen

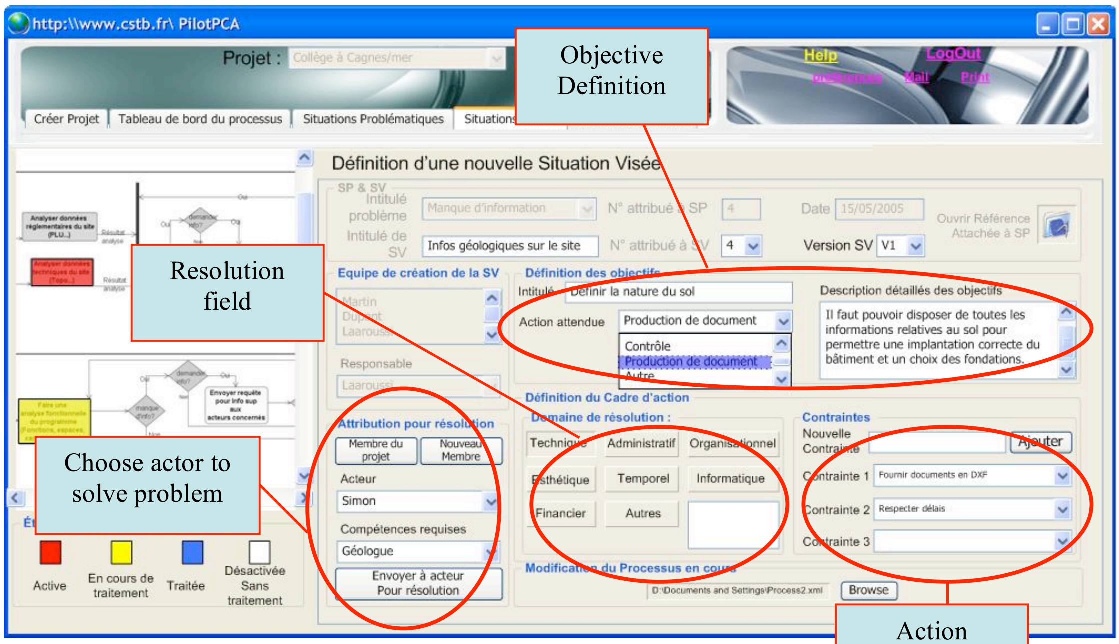

Figure 7 : aimed situation definition screen

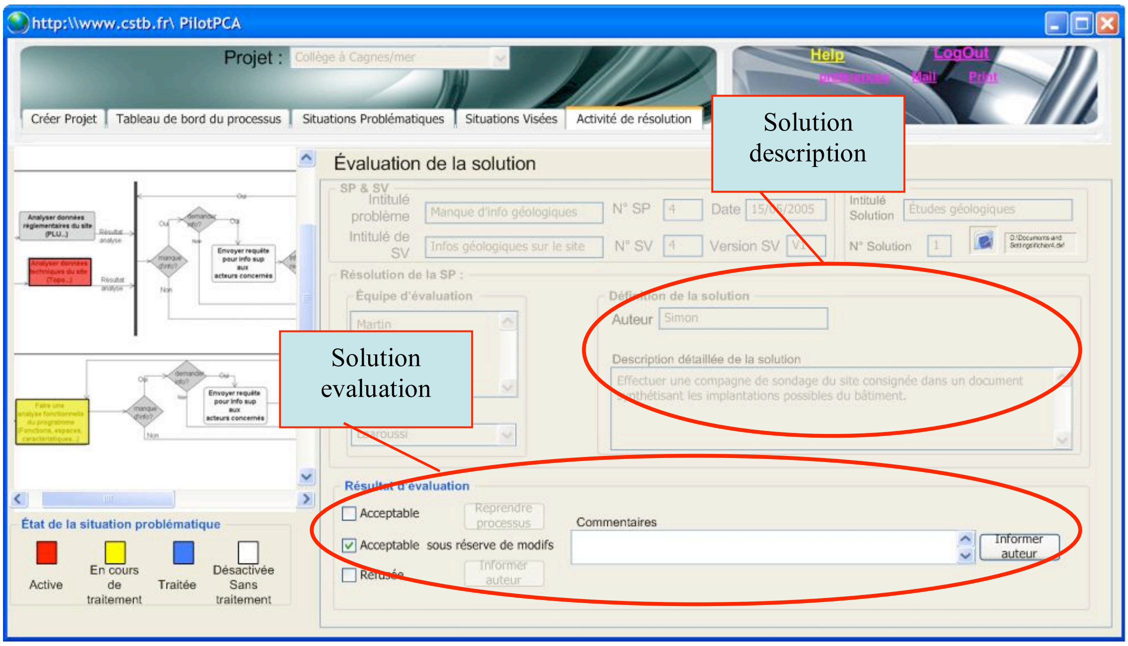

Figure 8 : evaluation screen

4.2. A SOFTWARE ARCHITECTURE DRIVEN SERVICES FOR THE DESIGN PROCESSES IN ARCHITECTURE STEERING

The software we propose to develop starting from our modeling aims to run and to steer the design processes in architecture. With this intention we propose to base our tool on a Services Oriented Architecture (SOA) structured in three modules (Figure 9).

- *Modelling module*: it is a module based on a graphic tool that is easy to handle by the pilot. It allows him to input the business processes of the different actors (e.g. tasks and their sequences, events, constraints, etc.) according to the macro model. The modelled business processes will then be coordinated by the pilot. In order to assist the pilot in this modelling, we propose a business processes library that integrates the experience of the actors. These processes can be customized (e.g. customized transition rules, missions, roles, events, tasks, etc.). Thus the pilot could draw from the processes libraries in order to customize the ongoing process.
- *Processes execution module*: it is a module allowing the transformation of the processes towards an executable model, like BPEL (Business Process Language Execution) (Andrews et al. 2003) or XML. This is achieved with the implementation of an execution engine and extension mechanisms of this engine by using Aspects-Oriented Programming (AOP) (Bachmendo and Unland 2001). Thus, we propose the installation of a dedicated engine based on a lower-layer-of-events oriented integration (e.g. Event Driven Architecture EDA). This will allow collaboration among various actors who can be initially human and in the utlimately resources.
- *Services development module*: it is a quality and performance supervising service of the design process in architecture (e.g. dashboard, alarm, data harvest services, etc.). It is therefore a question of installing the tools for collaborative services generation. These tools for automatic generation will be based on expertise and already existing tools like “manufacture software”. (Parigot et al. 2002).

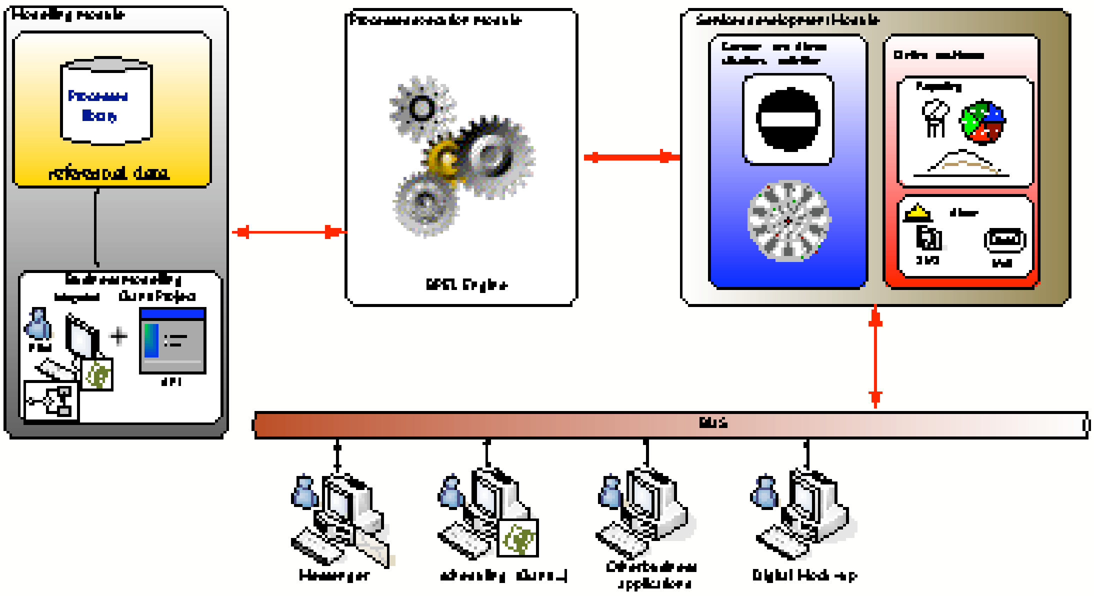

Figure 9 : a software architecture to steer design processes in architecture

This system aims to be used mainly by the pilot. However some screens can be used by all the design team members in order to declare concern situations, submit solutions, or track solving activities state. In this way access rights can be assigned according to the actors' profile.

CONCLUSION

Through our approach, we have presented a model for steering distributed design processes in architecture. The applicative objective of our research is to allow the pilot of the design processes to have a global view of the entire distributed design processes, while reporting to him on its dynamics (concept of dashboard). The pilot therefore has a tool that allows him to visualise the state of the processes and sub-processes in any moment of the design process. Thanks to the proposed software application, the pilot will be able to make the adequate decisions in order to reach the desired performance. Moreover, this research will contribute to knowledge capitalization through the project information system. This will be achieved by compiling into experience libraries all the dynamics produced during the design processes in order to use them for future problem solving in similar situations.

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