A Framework for Dealing with Dynamic Buildings

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ABSTRACT: The design world of architects and engineers is changing. Costs arising during the whole life cycle of a building are being taken into account. Therefore, complex tools to support design decisions are coming up, and an increasing number of experts from a great variety of disciplines will have to cooperate in a more and more interrelated and sophisticated manner. Our hypothesis is, that an integrated framework based on the metaphor of a "dynamic building" as component-based, spatial model will bridge between the information technical representation and the "classical" building planning. All planning, cooperation, usage, and aging processes of the building life cycle will be reflected in such a "virtual" dynamic building, for which we are developing an appropriate framework.

1 INTRODUCTION

The planning of buildings comprises the whole technical life cyle of a building from the planning , to the usage with running, maintenance, and renewal phases, to the restitution of buildings. Because of the semantical complexity of this process, many experts from a great variety of disciplines will have to cooperate in a more and more interrelated and sophisticated manner.

We will meet these challenges in an interdisciplinary way in collaboration of architects and computer scientists. Our hypothesis is, that an integrated framework based on the metaphor of a "dynamic building" as component-based, spatial model will bridge between the information technical representation and the "classical" building planning. All planning, cooperation, usage, and aging processes of the building life cycle will be reflected in such a "virtual" dynamic building, that will provide for an intuitive access to the complex and interrelated information for all participants of the planning process.

In the following, we will first describe our basic approach to model and transfer a dynamic building with an integrated cooperative framework into practice, and then propose a system architecture to technically realize our vision.

2 REQUIREMENTS

Our approach aims to realize the metaphor of a dynamic building in order to achieve the following main characteristics:

- Integration of all design data along the whole life cycle of a building, i.e. an integrated product model. Our approach proposes a kernel model, that is based on a so-called n-dimensional design space with the three geometric dimensions and additional building-design specific dimensions [1].
- Allowing for comfortable integration of design tools on demand, that will be based on a dynamic view handling mechanism.
- Support of cooperation, i.e. a flexible cooperation model, that will be based on the workflows of the building life cycle [2]. The cooperation management has to be adaptable and flexible and should be integrated into the working environment.
- Management of Constraints, in order to handle vague and incomplete information, as it is typical for early planning steps. The grade of consistency and of completeness will become higher during the goal-oriented design process. Detecting consistency violation is also a basic mechanism for cooperation support.

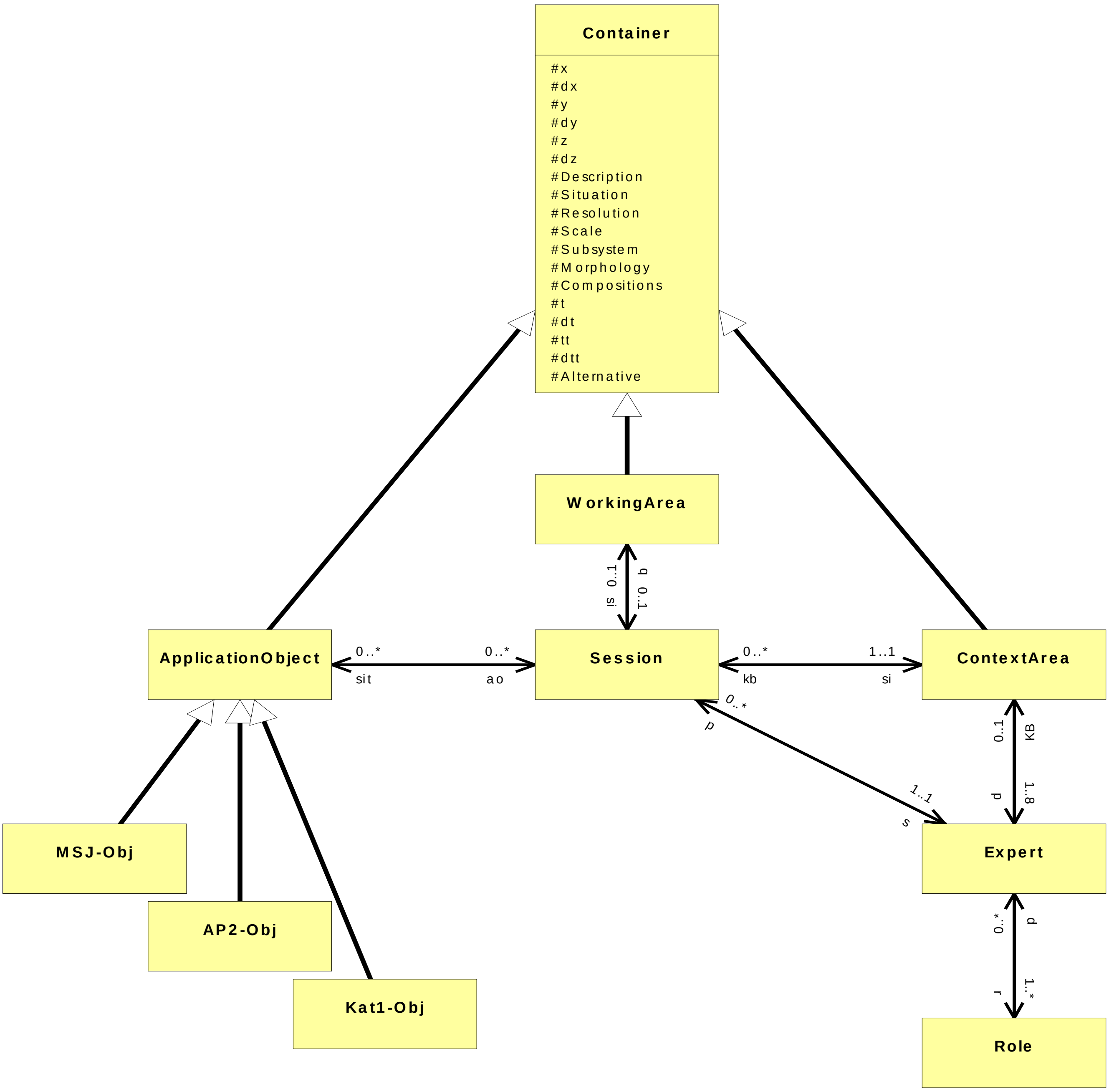
3 BASIC APPROACH

To meet the requirements we propose a framework for an integrated planning platform for dynamic buildings. The main idea behind our platform is the metaphor of a dynamic building, i.e. a component-based, spatial model supporting the cooperation processes not only by the spatial dimensions, but additionally, by various other aspects of the building life cycle. These dimensions form a kernel to integrate the product and process model in a cooperative planning environment. The technical realization transforms the metaphor of dynamic building to basic elements, so-called dynamic components. They support dynamics in the evolvement of the design:

- along time, i.e. change of the components,
- along space, i.e. working in a distributed environment, and
- along the life-cycle, i.e. change of the components during the life cycle time of the building.

The dynamic components will provide for a very flexible modeling as common basis of the design objects in the whole heterogeneous and distributed framework handling the life-cycle of buildings. In our work, we concentrate on the planning phase, but also from that point of view, we have to handle the later phases of the building life cycle. In future work, we will also analyse how our platform is suitable to support these phases.

Finally, the system architecture has strongly to support distributed and cooperative work using an integrating information base.



4 DATA MODELLING

Integration is especially important in the planning environment, because there are a large amount of experts involved in a large project working with a great variety of application tools, highly specialized to the task they are supposed to work on. Each tool works on its own specialized data model so that integration means in a first step integrating these different models by the integration platform in a suitable an easy way.

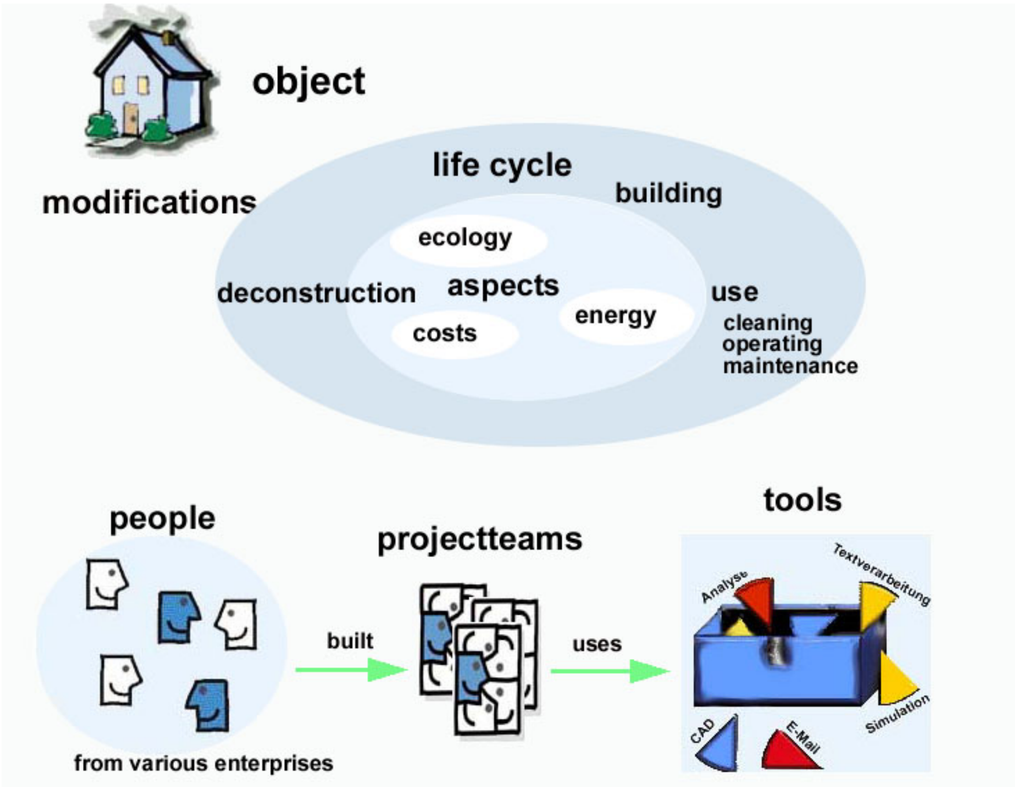
Analyzing the characteristics of these different models showed in a first term the close relationship of the objects to the spatial area in the geometrical representation of the design and additional to other dimensions of an multi-dimensional design area. As illustrated in figure 1 we isolated these area-related properties from the objects to a so-called Container class, which represents an area in our n-dimensional design space.

This Container class is inherited by all ApplicationObjects, independent of the concrete application the object belongs to. This way in our integration kernel each object has a kind of proxy object, that makes it visible to all other applications via our integration plattform.

Various interaction schemes can now be implemented by the detection of overlappings, the so-called collisions of different objects, even from different applications in our platform.

The common properties modelled by the Container class are also inherited by the WorkingArea and the ContextArea, which supports a cooperation model and the workflow of the design process. It will be further described in the next section.

Each time an expert wants to work with our planning platform, he or she starts by specifiying the area in the design space, where he or she wants to work on, the so-called WorkingArea. In the following the expert will get connected either by an online connection to the system, restricted to the specified area or by a copy of all objects, overlapping the sepecified area. In the latter case a check-in/check-out mechanism will track the changes to these objects.



5 SUPPORT OF COOPERATION

Building design is an inherently cooperative task, where a lot of experts from different organisations and from various disciplines are involved, see also Figure 2. Additionally to the above presented integration of data, there is the need for a more organizational support of cooperation.

The characteristics of a cooperation model in this context are

- Team-based cooperation.
- Mostly following an integrational as well as quality enhancing cooperation form.
- Supporting a cyclic and iterative process.
- Having a goal-oriented planning process.
- At most at the beginning, havingplanning process that is highly dynamic, handling

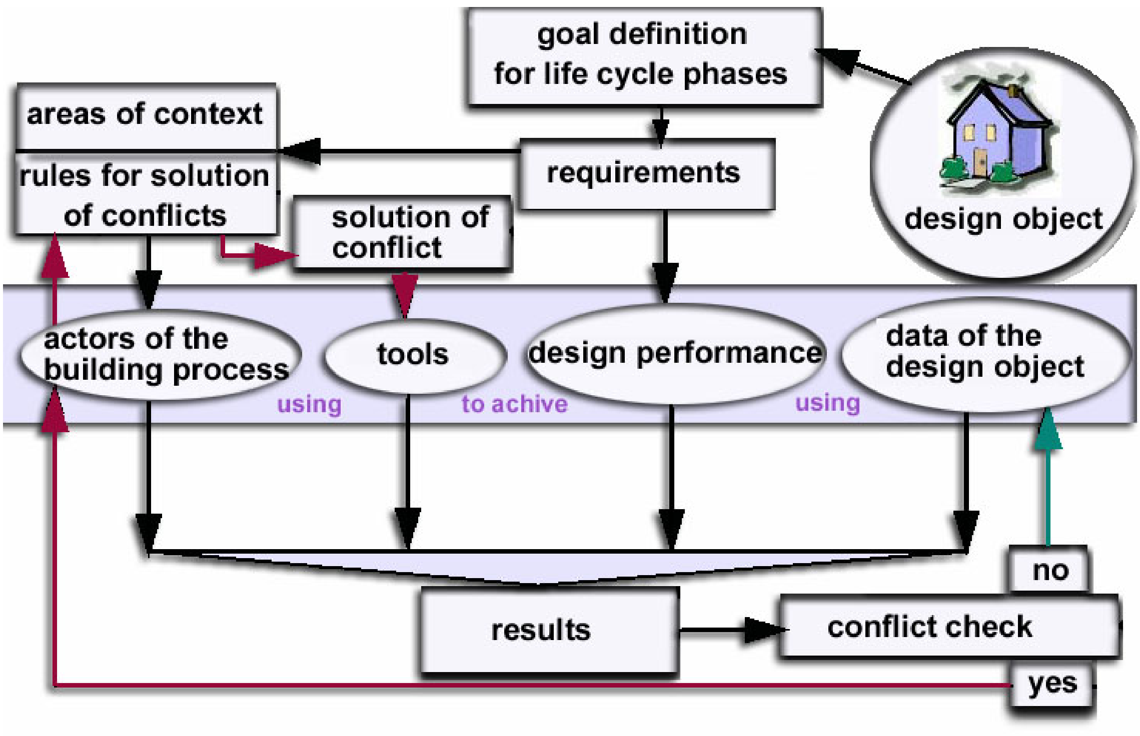
vague and incomplete information, that will basically affect on the cooperation model.

- Need to the management of objectives during the whole planning process.

Figure 3 sketches the relationships between the components of the planning platform in respect to cooperation support. The basis forms the common information base, which will consist of the design data and meta-information about the cooperation itself. Each participant will have a context and a dynamic information profile, that have to be handled explicitly in the framework. Conflicts will be handled by collisions of context areas and working areas of different experts. Our cooperation models also allows for defining rules how to handle conflicts between experts.

The system architecture in figure 4 is derived from an integrated Corba-based framework for CAD/CAM [3] and is organized in three levels:

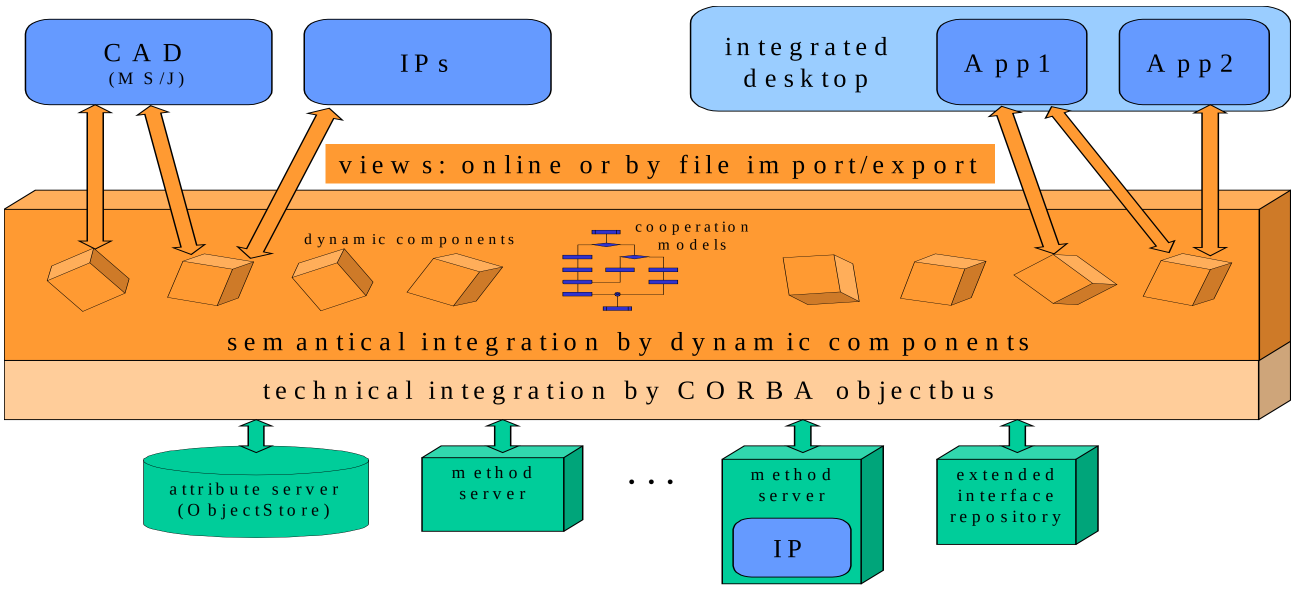
- The storage level, where we have distributed repositories, potentially following different data models, e.g., object-oriented, relational formats. These repositories store the design data, in form of attributes, interfaces and methods for the tools at the application level.
- The middleware level, where we get the technical integration using the CORBA standard, and the semantical integration with CORBA services and special enhancements, i.e. the dynamic components and the cooperation models.
- The application level, where we will couple various design tools. Some tools will be embedded into a so-called integrated desktop that delivers a framework-specfic interface and allows for fully integrating the tool, other tools will keep their special interface, like the CAD tool, so that we get a looser coupling of these kind of tools.



6 SYSTEM ARCHITECTURE

Realizing a framework for dealing with dynamic buildings requires to provide for a flexible, open architecture, that allows to integrate on demand new expert tools, for a distribution of the design data as well as of the clients, on which the tools are settled, and for cooperation mechanisms in order to achieve simultaneous engineering.

In our project, on the application level, we are integrating a CAD system, the Bentley MicrostationJ [4], and interpretational programs (IPs), e.g., a heat and energy analyzing tool, and a tool, calculating ecological figures [5]. In the second phase, we will add a prediction tool, that will allow to simulate during the planning phase the aging process along the building life cycle, so that design decisions may be based upon the



predicted development of, e.g., costs, ecological factors, need of energy.

7 SUMMARY AND FUTURE WORK

In this paper we presented a framework for an integrated planning platform for buildings. It is based upon the metaphor of a dynamic building, a component-based, spatial model supporting the cooperation processes not only by the spatial dimensions, but additionally, by various other aspects of the building life cycle. These dimensions form a kernel for the integration of the product and process model in a cooperative planning environment. The basic elements are identified as dynamic components. The system architecture allows to realize distributed and cooperative work using an integrated information base.

Futher work will focus on the validation and refinement of the rough protoype system, especially concerning the cooperation model, the integration of the product model, and the view handling component. On the application level, i.e., the planning tools and interfaces for the expert users, we will concentrate on investigating dynamical simulation models during the planning phase to be able to make design decisions according to the potential development of the building during the whole life cycle, as, e.g., predicting the costs coming up during the aging process by renewal or maintenance requirements.

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