A virtual life cycle structured platform for building applications

Petra Both, Niklaus Kohler, Robin Gessmann

Institute for Industrial Building Production , University of Karlsruhe (TH), Gemany

(petra@vonboth.de)

Summary

The development of a life cycle structured cooperation platform is described, which is based on an integrated process and goal-oriented project model. Furthermore the structure of a life cycle oriented object structure model and its implementation in the platform are documented. The complete conceptual model is described, which represents the basis of a lifecycle-oriented structuring of the planning object and supports the thematic classification of the object and project management data.

1 Introduction

In the field of AEC (architecture, engineering and construction) the consideration of the complete life cycle of buildings becomes more and more important. Also questions of utilization and energy and cost flows during the management of a building become more relevant (Kohler and Lützkendorf 2003).

Life cycle approaches in building derive from several sources: maintenance experience of buildings and infrastructures, monument conservation, Life Cycle Analysis and facility management. In contrast to the classical life cycle considerations of consumer goods, that assume 5 to 10 years for the whole product life, the building sector has to take into account a much longer period of up to 150 years and beyond.

Speaking of lifecycle oriented building design; the object planning has to take several decades into account. As a consequence thereof and of the predominant one-of-a-kind character of buildings, high complexity and 4-dimensional dependencies arise. This requires high standards to the planning process, because the constructive basics and planning decisions for the whole life cycle are developed and specified here.

The application of an integrated planning philosophy (IP), which pursues a life cycle oriented and holistic planning, represents one solution approach (Kohler 1998). By a vertical integration aspects of sustainability can be embedded in early design phases. The aim of this vertical integration is the involvement of knowledge of the concerned groups or actors and the thematic aspects of later life cycle phases in the design process. One example is the participation of the future residents or users by including their specific expectations and demands in the process of the specification of the project objectives. In the research project e_co-housing (Gessmann and Peter 2003) this is managed by different tools, which support the future users to define their priorities in terms of sustainability aspects as a basis for the design process.

The horizontal integration includes the keynote of an interdisciplinary problem solution and supports the thematic synchronisation of the separated planning processes. Thereby the different methods of various disciplines have to be applied and coordinated in terms of a quality check.

The application of such an integrated planning strategy and therewith resulting close cooperation has to be supported by the development of assisting auxiliary means and specific tools. Project oriented cooperation platforms can serve as an important communication base and improves the discussion and the thematically exchange of the project participants. Such cooperation platforms, which offer various groupware functionalities, are already established for the planning of new buildings (for example the German enterprises Conject and Kopsis). For the field of building process, object management and refurbishment several solutions are worked out by current research projects (Both und Zentner 2004, e_co-housing 2004, Gismo 2004). In the above-mentioned e_co-housing project, the platform supports for example the participatory design process including the future residents, the building process and will later on serve as a building managing tool for the utilization of the building.

This rather technology-based approach appears promising. In reference to recent discussions (ICCCBE 2002) it is obvious however, that an exclusive technological support, which is applied only to map existing structures and methods of cooperation, brings only a limited benefit to the product planning. Existing methodical approaches return no satisfying solutions to the specific problems of coordination in spatially distributed but still collaborative work. In order to achieve a real improvement it will be necessary to analyse the existing planning methodologies and organisational strategies in order to adapt them to the new requirements of integration.

2 The integral cooperation model

To cope with this integration approach, the coordination of spatially separated planning processes requires an explicit cooperation method with rules and auxiliary means. At the institute for industrial building production of the university of Karlsruhe a project model was developed (Both 2003), which is based on the concepts of system engineering. This model integrates the different aspects of object planning and project management and enables a holistic, goal- and process oriented accomplishment of a project in a team-oriented manner. It serves as a conceptional base for the development of the afterwards explained life cycle platform.

This project model, shown in figure 1, represents a kind of a building set resp. kit, which contains the necessary elements, structures and rules for the realisation and coordination of the development project. In order to cope with this integration approach, the various aspects of project coordination are worked out as partial models and are integrated in the superordinated model with regard to their interdependencies: The accomplishment of the performance in a planning project is effected by the execution of processes (process model), which modify the information flowing among them (model of information flow). The processes are initiated to achieve special objectives resp. to solve specific problems (objective and task model). All of these goal-oriented processes are executed by appropriated resources and are coordinated by special organisational roles (organisation model).

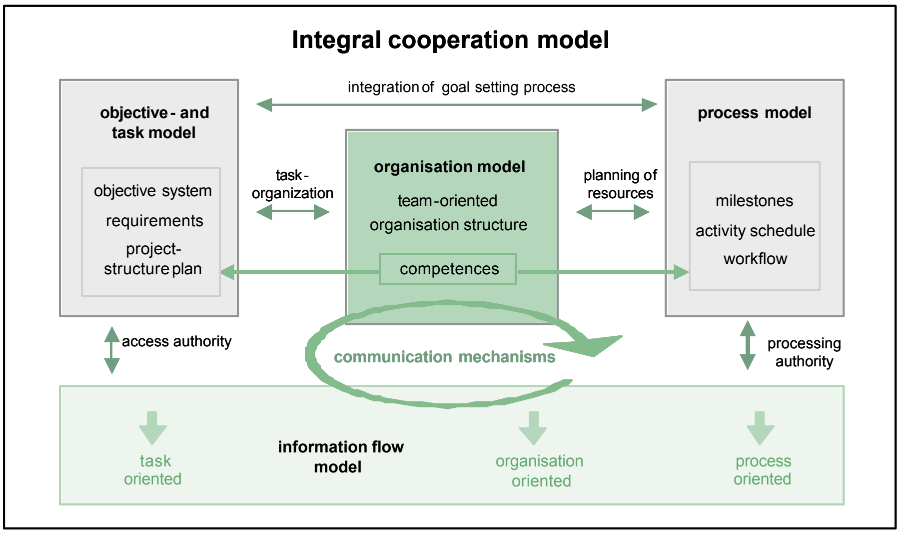

Figure 1: The integral cooperation model

During the strategic project planning at the beginning of a project, the product requirements are being transferred under consideration of the superior system into the project objectives. The result is a target system constantly specified and adapted in the later course of the project for each phase. To enable the control of the high complex project contents, the project must be consequently divided, starting from the target system into units, which are clearly presented and can easily be planned and controlled. Thus for each phase of the project a complete, goal-oriented structuring of the project is effected by the determination of all necessary work packages and their linkages in the context of the planning of the work breakdown structure. When the task structure has been build, the development of the team-oriented organisation structure can take place during the task allocation. After the estimation of effort the basis for process modelling is created via the transfer of task packages into logically linked operational processes.

The different subsystems are built directly on top of each other and must therefore be coordinated and integrated accordingly. The goal planning represents the basis of the entire project planning and additionally enables the administration of the purely operational-logical linkages to seize the content wise reciprocal effects.

3 Thematic Synchronisation by an Integrated Object Structure Model

For the warranty of an adequate thematic coordination and synchronisation, the exclusive consideration of organisational and operational structures on the basis of the project model is not sufficient. Here it will be necessary to document and manage the thematic context and the content-oriented interdependencies of the spatial separated processes as a kind of configuration management.

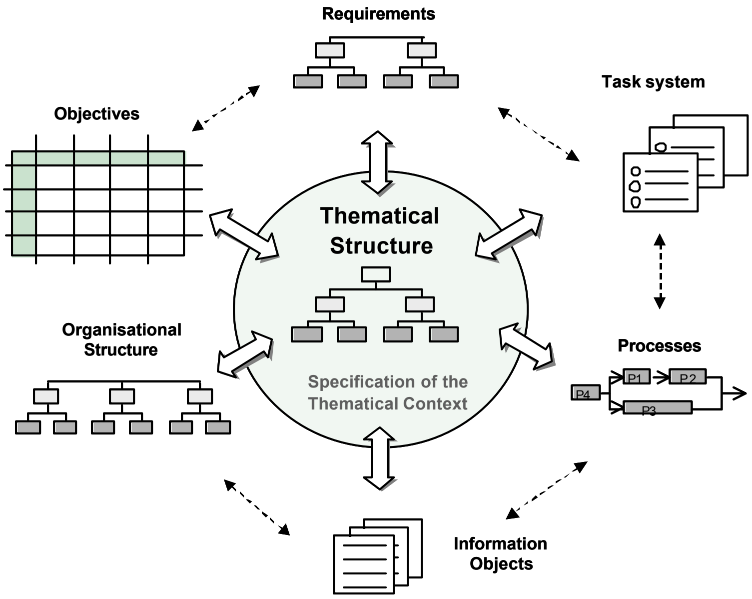

Figure 2: Specification of the thematic context by a thematic structuring

To reply the question, how this thematic context can be described, an abstract consideration will be necessary at first: In the field of system engineering a project is defined as an object transforming action system, whose main function is the transformation of an object system from an original state to a defined target state with supply of adequate resources. The project functions serve for the transformation of the object defining parameters (material, energy, information and costs) and change the state of the object system (figure 3).

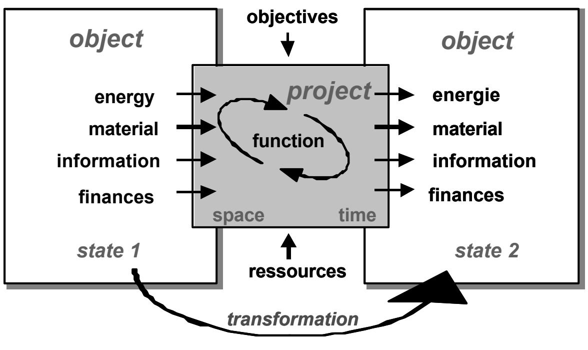

Figure 3: The project as an object transforming system

Derivated by this consideration, the thematic context of a project and its processes can be described by this object system. In addition to the shown project model thus a so-called object structure model (Both 2004) was specified, which represents the planning object and its structural relations over the progression of the project. This object structure model, shown in figure 3, consists of a semantic network of so called structure objects.

Further to a methodical object planning strategy (Both 2004), the structure objects describe the planning object by its functional structure, by its elements resp. components and system parameter as well as by the spatial room structure.

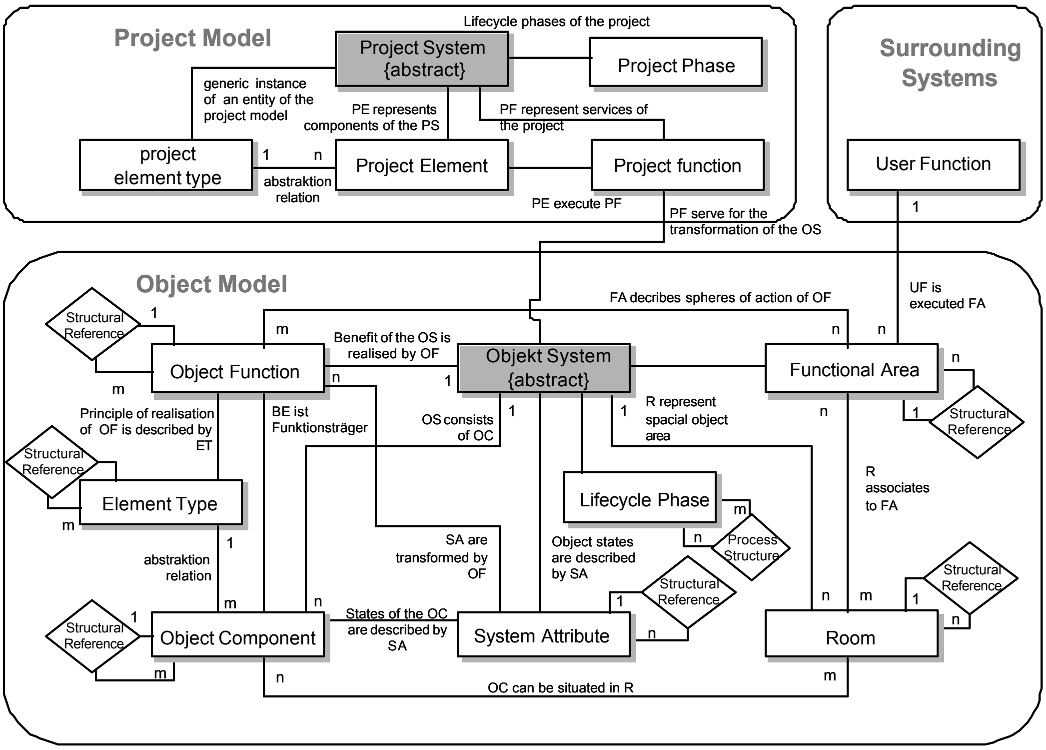

Figure 4: System of structure objects

The specified structure objects serve as classification criteria's for the post-coordinative thematic structuring of the planning and management data of the project and constitute a kind of "structural coordination level" for the elements of the project system. This thematic concatenation of processes, requirements and information to the various object components or spatial areas enables a thematic synchronisation of the planning processes. Thus it allows the dynamically generation of context-oriented thematic views of the project information (product and management data) and its coherences during the running time of the project, like a simplified product and project data model.

Furthermore the object oriented classification serves as a basis for a goal conflict management (Both 2003). A fundamental condition for the handling of goal conflicts represents the detection of existing thematic and content-oriented overlaps resp. interdependencies. These thematic interactions can be described by the explained correlation of the objectives and requirements to the explained structure objects. The object and its components represent the reference object of the conflict. The system parameter describes the colliding object attributes.

4 Validation by an internet based prototype

The model has been validated by the implementation of an Internet based software prototype. This integrated web-based project platform *SyProM* (Both 2004) has been developed as an assisting tool based on the groupware system Lotus Domino ®. The graphical user interface (figure 5) offers in accordance with the described partial models the access to different modules:

- The module „objectives + requirements" allows the specification and coordination of the relevant objective target and offers functionalities for a methodical support of the process of the objective development (objective planning pilot).

- The management of the project organisation with the administration of the participants and the organisational roles takes place in the module “project organisation“.
- The management of the project relevant tasks and the conceptual formulations will be supported in the module „task management“.
- The module „information management“ enables an efficient information flow among specified information logistic structures and offers flexible access and distribution mechanisms. So-called “content objects” manage the created planning information, which contains in addition to the actual information describing Meta information.

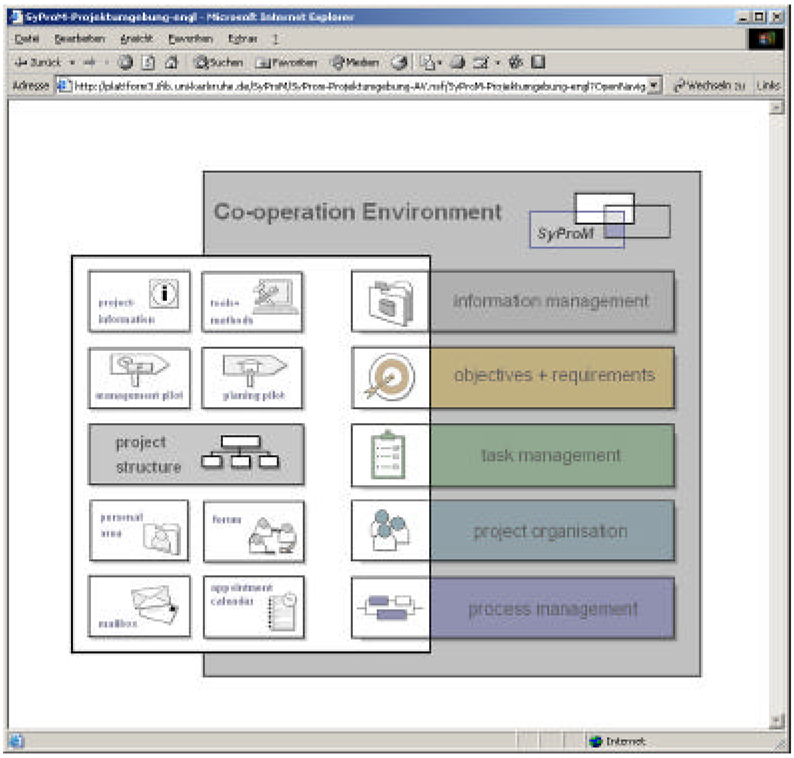

Figure 5: GUI of the prototype

In the module „project structure“, the development and management of the structure objects is supported, which serves as thematic classification criteria’s and primary represents the virtual planning object.

The association of these structure objects with the cooperation elements resp. the thematic classification of the objectives, requirements, tasks or information can be done in the different management modules. The following figure 7 shows a screenshot of the thematic classification of a requirement by using an interactive checklist of the according structure objects.

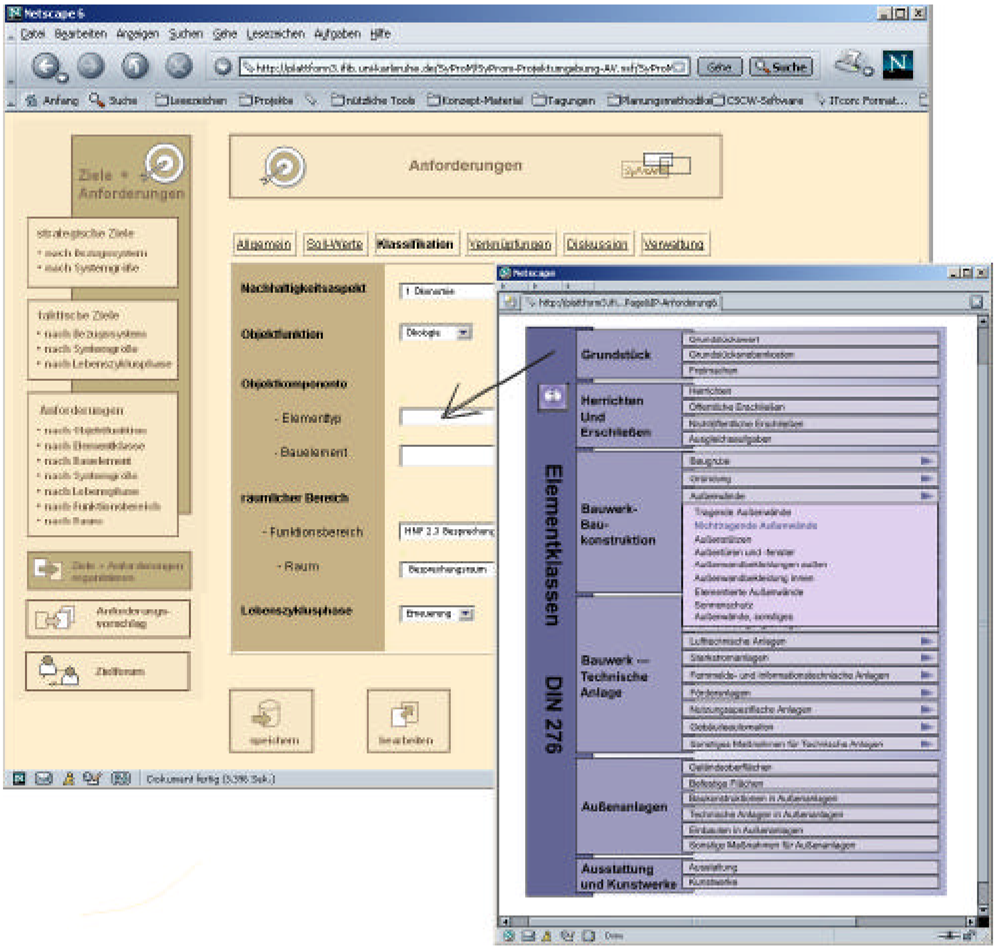

Figure 7: Thematic classification of requirements

4.1 The Room Book as lifecycle reference

The room-related viewing resp. description of the building represents an important reference unit over the whole lifecycle. Especially for the period of building production and utilisation aside from the produced elements the room is in the centre of attention. To supply such a "room-oriented way of thinking", it seems to be necessary to store and manage the project information and planning results in concatenation to the according room. In the area of building planning and object management referring to this the term "room book" (Hepermann 1994) has been established.

The here explained prototype supports by dint of the explained room-related classification of the planning information the generation of room-oriented views as contemplated by such a room book. The following screenshot shows the graphical user interface (GUI) of the room book.

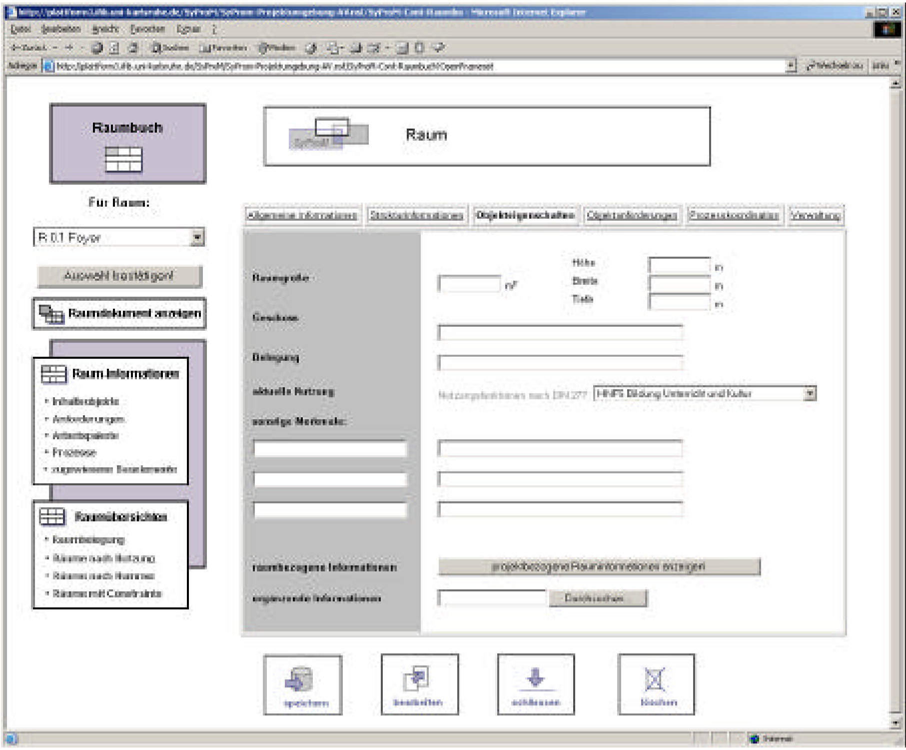

Figure 7: GUI of the room book

In this room book, in addition to several thematic room overviews (e.g. rooms by occupation or rooms by utilization) information of the concrete rooms can be presented. Moreover the direct access to the document of the selected room and the therewith-stored Meta information is provided. Also views to all planning information (module for information management), related to this special room, are presented.

Furthermore the content of the room book can be upgraded by the application of the explained room-oriented structural mechanisms also to the management data of the project in such a manner, that in addition to the room-oriented preparation of object information also room-oriented views to the cooperation's objects, like tasks, requirements or processes of the project can be provided. As shown in figure 7, thus all for a selected room relevant requirements are presented in a dynamic runtime-generated list. Also the room-related tasks and processes can be accessed.

5 Integrated lifecycle approach

The explained approach tries to solve the problem of the life cycle integration with a life cycle oriented goal and requirement modelling. This creates the possibility to include aspects and thematic coherences of later object-life-cycle-phases already in the design-phase and use them as binding design parameters. The focus is here also on the system "project", because it serves as reference system.

Due to the predetermined (temporal) system borders of the project, problems in terms of the allocation and commissioning of information and objective targets of the design object to the following life cycle phases occur. The temporal system border of the project should not narrow the consideration spectrum. As a result of sustainability aspects, the life cycle orientation consequently demands a post project consideration.

The conceptual problems, which have to be solved, are quite new: Life cycle consideration implies extended system limits in space (integration of the planning object in the ecosystem) and in time (from 0 to more than 100 years). Time aspects become important implying different time scales (from hours in energy and construction modelling to years and decades in object maintenance and economical calculation). In parallel to these extended system limits, knowledge about life cycle aspects derives from different context areas (time, space, actors).

Based on the current results of SyProM and other ongoing projects, the drawn conclusions for the structure of a lifecycle oriented platform is the differentiation of the project and object level. Thus the aim is the development of a lifecycle-lasting object platform, with which several phase-oriented project platforms will be interlinked (compare figure 8). The interconnection can be realised by an upgrade of the explained structure level. The explained structure objects can effect the specification of the request resp. problem context.

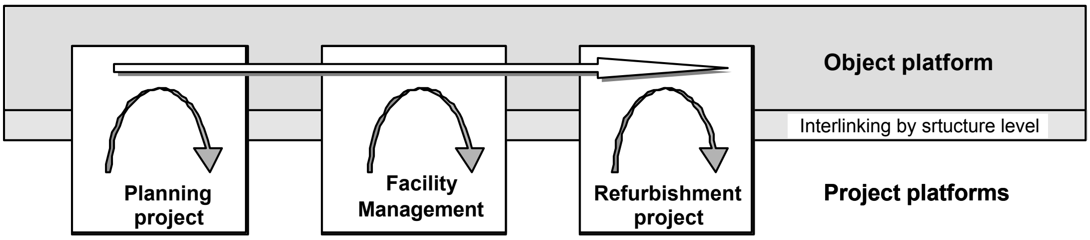

Figure 8: Interaction of different project platforms with the object platform

The object platform serves for the management of the object information (reference values and existing information) over the whole life cycle and represents a product data repository level for all life cycle relevant data. In addition it provides a dynamic structural frame as base of a configuration management. This enlarges the transparency of the thematic coherences over the changing life cycle phases and serves as a basis of thematic synchronisation.

The connected project platform allows the access from any life cycle phase to the mapped superior thematic coherences and aspects kept in the object platform (e.g. *goal conflicts*). This kind of knowledge management level allows the integration of the knowledge of the thematic coherences of other resp. later lifecycle phases in the different projects. The thematic project structure can directly be derived out of this structural object context. A simple visualisation of these interactions is shown in figure 9 with different tiers for the thematic context and the derived information.

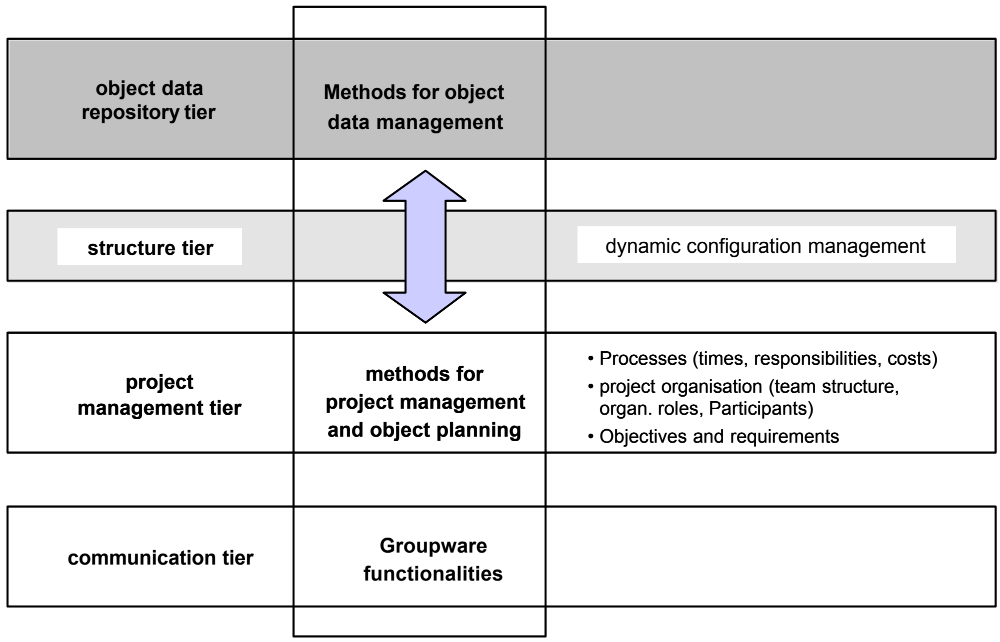

Figure 9. Different tiers of the interlinked lifecycle platforms

The project platform supports the coordination and accomplishment of the object transforming processes and provides the management frame for the object planning as a project interior performance. The representation resp. logging of the object transforming processes (project functions) and the herewith-effected state modifications of the object system over the whole life cycle enables a structural dynamic sampling of the object model.

The further development of this life cycle object platform will be substance of an upcoming doctor thesis at the Institute for industrial building production (University of Karlsruhe).

6 References

BOTH, P. v. (2003). A methodical process model for a cooperative planning of complex products. In KAAPKE, Kai (Eds.); WULF, Alexander (Eds.): *Forum Bauinformatik 2003 : Junge Wissenschaftler forschen.* 1. Auflage. Aachen : Shaker Verlag, - Forumbeitrag. - ISBN 3-8322-2022-4

BOTH, P. v. (2002). An Internet-based Co-operation Environment for a dynamic project development; ICCCBE-IX : The 9th international Conference on Computing in Civil and Building Engineering, Taipei

BOTH, P. v. (2004). Ein systemisches Projektmodell für ein kooperatives Design komplexer Unikate. Presented manuscript of dissertation, Institute for industrial building production, University of Karlsruhe (TH).

Both, P. v., Zentner (2004). Abschlussbericht des BMBF-Verbundprojektes LuZie – lebenszyklusorientierte Einbindung der Zielplanung und des Zielcontrolling in den integralen Planungsprozess, Institut für Industrielle Bauproduktion, Universität Karlsruhe (TH)

e_co-housing (2004) <http://www.eco-housing.org/>

Gessmann, R.; Peter, M. (2003) Eine lebenszyklusorientierte Planungsplattform zur Unterstützung partizipativer Wohnbauprojekte. In KAAPKE, Kai (Eds.); WULF, Alexander (Eds.): *Forum Bauinformatik 2003* : *Junge Wissenschaftler forschen.* 1. Auflage. Aachen : Shaker Verlag, - Forumbeitrag. - ISBN 3-8322-2022-4

GISMO (2004) <http://www.gismo-projekt.de/>

Hepermann, H. (1994). Vom Projektstart zum Pflichtenheft – Das Raumbuch als durchgängige Struktur. In Congena Texte 1/2

Kohler, N. (1998). Sustainability of New Work Practises and Building Concepts. In Streitz, N., et. al. (Eds.): Cooperative Buildings – Integrating Information, Organisation and Architecture. First international Workshop on Cooperative Buildings. Lecture Notes in Computer Science. Springer: Heidelberg

Kohler, N.; Lützkendorf, T. (2002). Integrated Life Cycle Analysis; in: Building Research & Information 30(5), 338–348