Product Model based Communication between Applications

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One of the goals of **so** called intelligent IT surely is to **come** to solutions for computer systems and working environments that are close to the human kind of thinking and doing work. What are the implications of that goal on integrated IT solutions for AE?

Not only since computers are in use of architects and engineers, the design **team** is trying to achieve the **goal** of an integrated design. The traditional integrated design process is based on communication between the **persons** forming the design **team.** The quality of the integration directly depends on the quality of the communication. This traditional communication process is done by exchanging sketches, drawings, calculations, descriptions and the spoken word. The design team consists of **various *specialized*** members, with very different engineering education and skills. This results in very **specific** technical terminologies and understanding of the meaning of the "design objects". How are these specialists able to communicate inspite of that for **an** outsider sometimes Babylonian confusion of tongues?

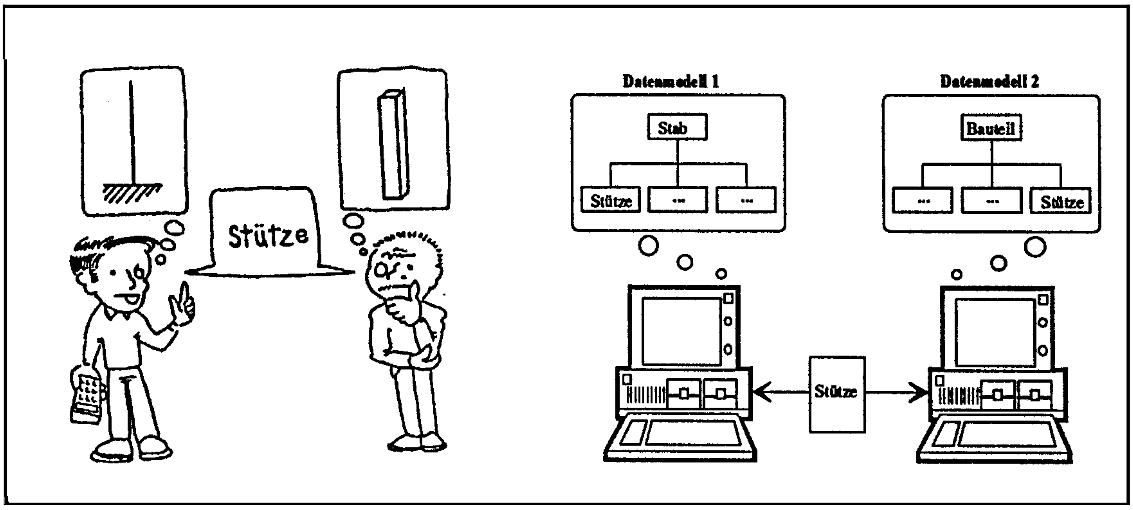

Fig. 1. : Data model and Communication

The avoidance of this confusion is based on the existence of "brain implemented data models". These models help those specialists to understand at least the implications that a certain designed part or solution will have on their **specific** design **tasks.** In fig. 1 it is the implication ***of*** a column to structural engineer and architect. Today the design is more and more aided by using computers. But does this necessarily demand an other new way of doing integrated design?

Since a long time there are ongoing discussions on integration and integrated systems as well as efforts to create those. Since some years there is at least a broad understanding that the key to intelligent data exchange, integration or communication is a conceptual model or better a product model. This understanding is surely not created by the STEP activities. It rather has the same roots, that even STEP is built on, but on the other hand STEP nowadays is surely THE promoter for such ideas. STEP is a standardization project that doesn't standardize something that emerged from the market [1]. STEP creates a standard from scratch, an urgently needed technical solution and this naturally takes a long time to do. But in the end, will it really do what it is expected to do? STEP is creating so called Application Protocols as the means to integration or communication. These AP's are more or less very large, very costly and most probably, once official, inflexible constructs. Will the way, STEP prefers to reach integration or communication between applications, really achieve what is desired by the design team?

What is it that we really expect from IT solutions for AE design? Is it really the creation of integrated design that is integrated? Are these the tools that are used in design, that when being integrated ones will create integrated design? Or is it rather the result that we are wanting to be an integrated one?

Is the AE design team not characterized by the fact that it is a new composition for each design which is a one of a kind design? Will it be possible to create one and only one coordinated and possibly standardized set of data models for integration and communication in the design team?

The way, how human techniques of communication between specialized experts in AE works, has to be the model, the goal. That is a demand for communication between very flexible and changing data models. Without a technique for communication between not standardized even not coordinated data models a data model based communication will be far from matching the required adequate solution.

In Esprit project COMBI some steps towards the desired direction are being undertaken.

The project

COMBI is developing a prototype environment for cooperative design which is mainly focused on the domain of structural engineering. It envisions an intelligent environment based on the idea of "integration by communication". One focus is the development of four application tools for structural design. A second focus is "integrating" these four plus linking them with an external traditional CAD System, which is done by a product model based approach with adopt STEP methodology.

COMBI objectives include the development of a flexible common representation framework capable of integrating multiple knowledge sources and modeling perspectives in building design. Systems based on latest technology for design assistance as well as existing numerical computation applications and traditional CAD systems shall work in an integrated or better cooperative manner.

COMBI agents

The COMBI prototype environment foresees the integration of several design agents. They represents characteristics of the design objects typical for their respective design domain. Although based on similar sets of design object classes they are not directly compatible with each other.

- Geotechnical Soil & Foundation Expert System
- Knowledge based Preliminary Structural Design
- Integrated Analysis and Dimensioning
- Reinforcement Design Expert System

These agents or application tools forms a kind of information chain, containing the forward- backward flows typical for iteration processes in building design.

The models

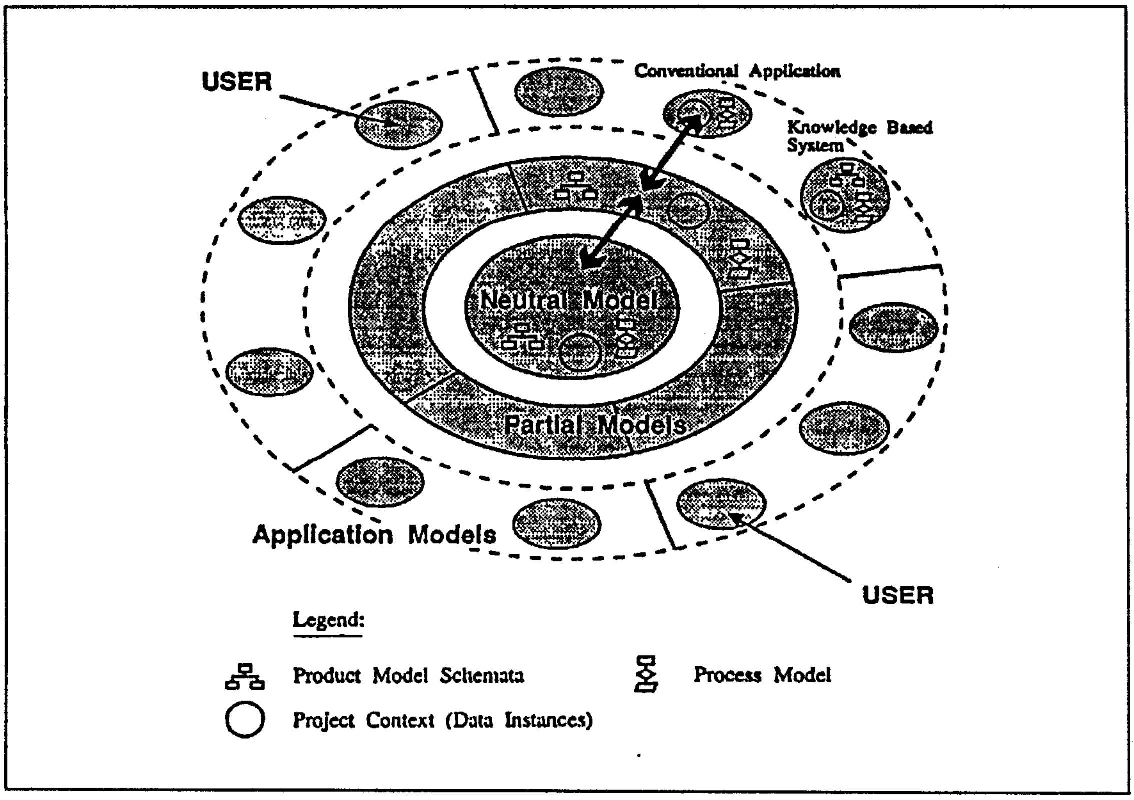

Fig. 2. : Schema of the modelling frameworks

For the modelling task a framework (fig. 2) has been created so that the evolutionary multi stage and multi agent nature of the design process can be taken into consideration in a unified integration approach. The architecture of the framework can be represented schematically by three hierarchically structured levels. It can be envisioned as a network of computers and users, where communication and coordination is achieved through a shared information medium and a control mechanism which provides facilities for the integration of loosely coupled design tools. The application tools that support the work of the individual designers are on the outer most level of the integration framework. They are their primary means to communicate with the integrated system. Each application tool has its own, application dependent product model, which need not necessarily conform to a standardized product model specification. The application data are processed and stored only within their application domain three main reasons for this are:

- the application data structure must be organized according to the needs of the application methods to achieve maximal run time performance.
- existing tools must be integrated without internal modifications.
- specific data extensions needed by the application methods are often only for limited temporary use and can be generated automatically, e.g. by finite element mesh generators, as is indeed the case in the COMBI prototype. Thus, information explosion and unnecessarily complicated data structures can be avoided.

The two inner levels are forming the common kernel of the integration framework. The kernel consists of a general neutral model and several partial (aspect) models.

The communication

The object oriented product model is the main kernel of the "integration by communication" concept of COMBI. A second kernel is a coordinated layer and attribute structure. This is used for linking the product model based application tools with a traditional CAD System using layers and attributes as a means for structuring their data.

The prototype environment of COMBI is closely modeled to the way, building design teams work in practice with their appropriate application tools.

The communication between COMBI application tools can not and shall not be compared with the solution from STEP, with Application Protocols. COMBI on one hand doesn't have the resources to follow that approach, on the other hand it seems to be necessary to look for more flexible methods. Methods that come closer to the way integrated design is done in practice. So COMBI's "Application Communication Models" can not be compared with STEP AP's. They simply contain all possible output/input entities and their attributes from one of the COMBI applications tools, so they are not designed for communication. A positive side of this disadvantage is that now there has to be a kind of intelligent center, a tool capable of filtering the incoming information for use in the receiving system. This will be done by a "model mapping" technique being able to build a superset, as well as knowing the origin of the entities respectively their attributes. This will avoid the time consuming and costly development of "COMBI AP's" and is an experiment for a small scale flexible model based communication.

A model mapping tool (fig. 3) is based on the exchange from instances between neutral files from different models. The quality of a model mapping tool is on one hand dependent on the similarity of the models and on the other hand on the intelligence of the communication mechanism.

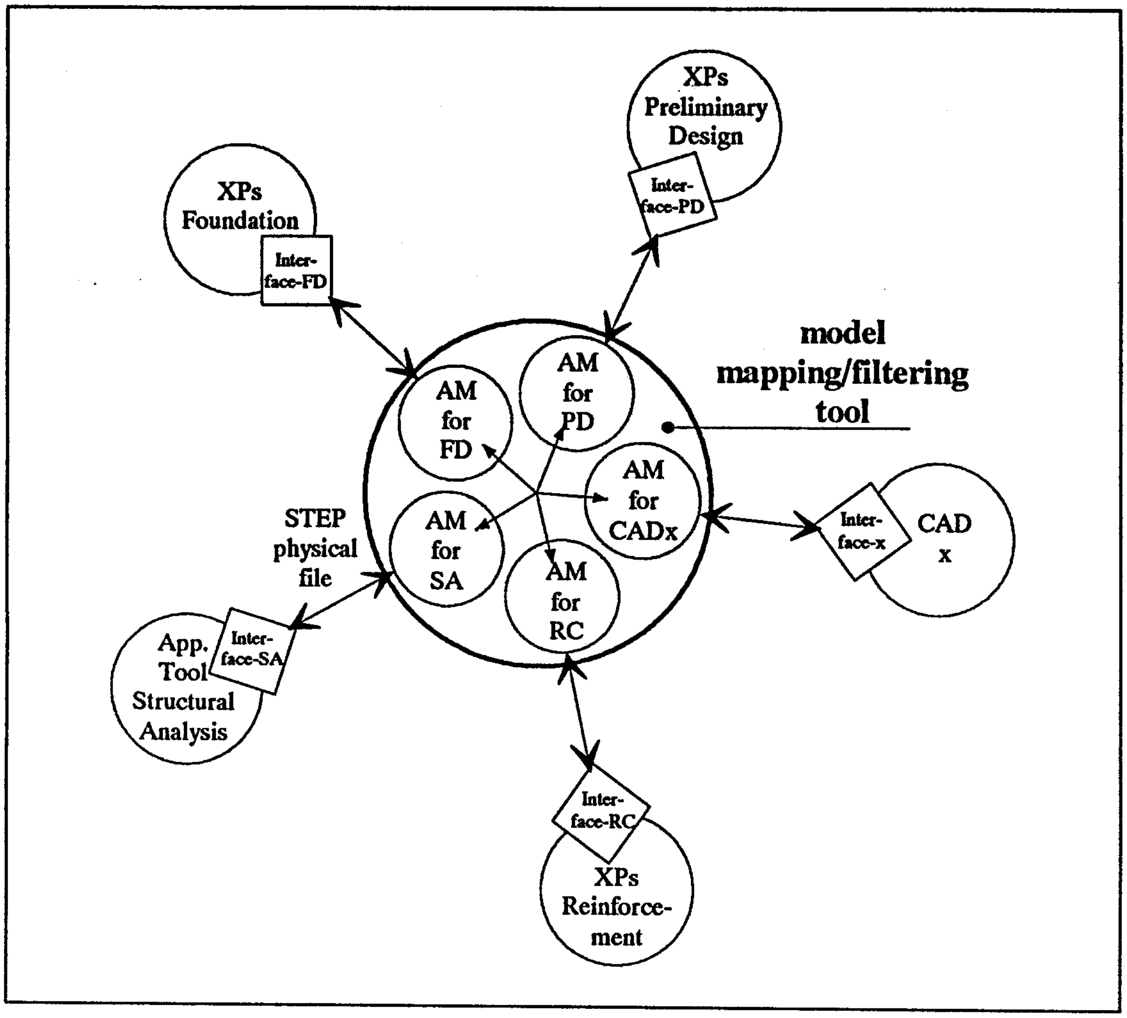

Fig. 3. : Communication with model mapping

The lowest level of communication mechanism uses the same names of entities and attributes within the participated models. That means for example an instance of the attribute *material* of the entity *column* within the model *Preliminary Design* shall be transferred to an instance of the attribute *material* of the entity *column* within the model *Structural Analysis*. It isn't necessary that all attributes of the entities are identically, only the instances of the attributes of the receiving model, which have a corresponding attribute of an entity with the same name in the sending model, will be transferred. This simple communication mechanism needs a lot of work for unifying the models. That means this method will be only realistic in practice, if modeling work for the participated application models is done together. But normally communication is necessary between models, which are developed in different environments and at different times.

If the models are not unified, then the communication mechanism will have to be more intelligent. The communication mechanism have to know rules to transfer instances which are built in different ways in the models but which have the same meaning. It seems to be possible to build common rules and to fill them with specific attributes and entity names of the two particular models. One simple rule is an 1:1 transfer from instances of attributes which have the same meaning but different names, for example an instance of the attribute *material* of the entity *slab* within the model *Preliminary Design* to an instance of the attribute *material name* of the entity *beam* within the model *Structural Analysis*. Another kind of rules make decisions about the domain of instances, for example an entity *rod* of one model can only be transferred to an entity *column* of another model, if its height is more bigger then the diameter. If attributes of different models have the same meaning but different units, it will be necessary to include a mathematical operation into the rule. Another kind of rules is required, when the same information is modeled as an entity with an attribute (e.g. its value), but has to be transferred into a pure attribute of another entity too another model, and vice versa.

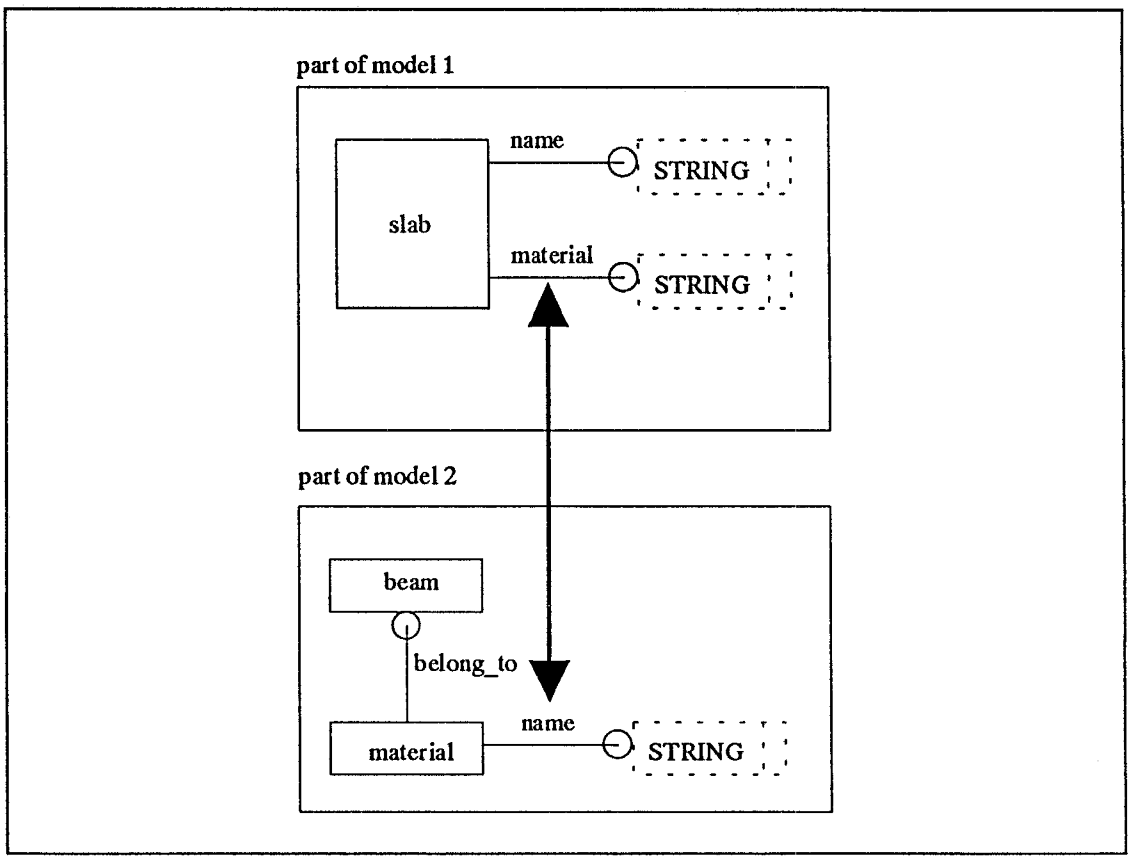

Fig. 4. : attributes with the same meaning but different definitions

In this example (fig. 4) the instance of the attribute *material* of the entity *slab* has the same meaning as the instance of the attribute *name* of the entity *material* which *belongs to* the entity *beam.*

Inside COMBI a second part of communication is based on a layer and attribute structure for traditional CAD systems, which are not model based. With a standardized layer and attribute structure it is possible to have a more effective data exchange between the participated applications with common data exchange formats. It is intended to realize one part of this data exchange also with the model mapping tool, that means the traditional CAD system will become one of the agents in the COMBI prototype.

Possible exchange formats for the CAD systems are AP201 [4] or STEP_2DBS [5]or a emerging 3D format. It is a fundamental prerequisite that the objects of the CAD system are structured in a defined way. The usable method for structuring these objects are layer and attributes. For the mapping between the CAD system and the application models it is necessary that the layer and attributes are structured in accordance with the participated models. In COMBI it has been decided, that one part of the layer name is the same as the name of the according entity class in the model, but only for those entities, which are relevant for data exchange with the CAD system.

A visualization of one and the same entity on three levels is planed. This requires a parallel visualization in the application model itself, as an instance in the neutral file and in a CAD system where the entity is placed on its layer . Necessarily there is a common basis in the way naming entities and layer. This will be achieved by identical names or by synonym tables.

Conclusion

The authors assume a loose integration of relative independent modules will be particular suitable for small and medium scale design tasks, which are the average of the daily work by architects and engineers and which are done by the help of commonly available software tools. The model mapping appears to be an appropriate concept to achieve an easy as well as effective integration of design data. More sophisticated design environments, incorporating constraint propagation and process control, can be built on top of this.

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[2] COMBI ESPRIT III - Project No. 6609
Object-Oriented Product Model
Task A2 : Concept of the OOPM

[3] COMBI ESPRIT III - Project No. 6609
Layer and Attribute Structure
Task A2 : Concept of the LAS

[4] ISO CD 10303 Product Data Representation and Exchange
Part 201 Explicit Draughting

[5] Haas, W.
STEP_2DBS (STEP-2D Building Subset)
An Interface for the Exchange of Drawing and CAD Data in Building

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