THE ARCHITECT'S DATABASE

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ABSTRACT

Architectural design deals with issues of widely varying nature: aesthetical and spatial issues, detailing, material choice and systems design, having a strong impact on the cost of operation, repair and maintenance. Information technology in construction industry provides new possibilities of reusing design solutions thus supporting some aspects of the design process. The main purpose of our project is to investigate methods for structuring the information related to architectural work in order to support the process of reusing design solutions. An equally important task is the development of a concrete application of a comprehensive archive of components in an object-oriented relational database. The basics of the architectural work are shortly discussed and an outline of a database called a Kit of design parts is presented. Also, a comment on multimedia as a way of integrating the various kinds of information needed in an architect's database is made. Finally, the conclusion is drawn that information technology will be one of the most important challenges facing the architect's profession during the years to come. Nevertheless tools like the Kit of d. p. will become vital tools that will help the professional to fulfil the new requirements.

1. THE ARCHITECTS NEEDS OF A DATABASE

1.1 INTRODUCTION

During the last couple of years the use of computers in architectural design in Sweden has grown into a dominating method to produce drawings. In spite of the fact that we are facing a crisis within the construction industry that has brought about a considerable decrease in the number of architects of most architect's offices, the use of computer-aided design has increased dramatically. Today the offices use more workstations than two years ago despite the fact that the staff has been reduced by 50% and now CAD is used in three times as may projects as two years ago.

Still, CAD is used mainly as a draft system but there is a strong and growing interest in using computers and software as a design and information system. You can identify three different categories of needs: the use of computers to visualise the designs, communication technology to make it possible to share information between different consultants and between different offices within one company and the use of databases as different kinds of archives. At the Division of Computer Aided Design and Visualisation at Chalmers University of Technology we are working with a system that we call a Computer Organised Kit of Design Parts which is meant to answer primarily to the needs of databases. The project is financed by the Swedish Council for Building Research and is part of the research program conducted by The Centre for Information Technology in the Construction Process at Chalmers.

The framework of the project Computer Organised Kit of Design Parts as well as issues on design process have been discussed by Lindgren (Lindgren, 1992). The development of a conceptual representation of the Kit of d. p. that should be discussed in the complex of the project, construction and management processes has been an important part of the work carried out. Discussions of this kind bring to the fore issues concerning the nature of the architect's work and the construction industry's future trends. There is an extensive choice of references on the architect's work as a design process but questions about the future of the construction industry cannot be answered with certainty since we today stand in the middle of a crisis. The crisis indicates some possibilities for a development in essential, qualitative respects and therefore the Kit of d. p. should have a high degree of adaptability to new methods. An example of the ability to adapt is the adjustment to the new requirements for quality assurance in the construction process. The most essential components of the Kit of d. p. are CAD-software, a database where procedures may be stored and a graphic interface allowing the user to store and retrieve the information needed in a systematic way.

The main purpose of our project is to investigate methods for structuring the information related to architectural work in order to support the process of reusing design solutions and the way they can be arranged within a library, as well as to develop a concrete application of a comprehensive archive of components in an object-oriented relational data base. In order to be successful in this undertaking one ought to understand in detail the user's needs and the nature of the activities to be supported. In the following we are going to discuss the basics of architectural work, look at an outline of a database called a Kit of d. p. and finally make a comment on multimedia as a way of integrating the various kinds of information needed in an architects database.

1.2 ABOUT THE ARCHITECT'S WORK

The architect's profession alike engineering, is considered a "prototypical example of design profession" (Goel and Pirolli, 1989). But as any other field architectural design has its own professional culture and peculiarities which, we feel, have to be taken into account when developing the Kit of d. p..

Architects are concerned with issues of widely varying nature: aesthetical and spatial issues, detailing, material choice and systems design form the frame of the architectural design. It has been identified as "a multi-faceted occupation" in which "groups of people work towards a somewhat ill-defined goal in a series of successive approximations" (Landsdown and Maver, 1984). The process of conceiving a design solution is not a sequential one even though it begins with a general discussion about goals and statements and ends with a specification of the designed artefact. The architect goes on elaborating the design until a design

specification including all the systems, parts and details necessary to create a building, is achieved.

While working with a design solution the specified goal/objective becomes more explicit, may be modified and new goal(s) may be selected. Conditions change often and as the work on the building design proceeds new conditions emerge. The architect becomes aware of new relationships and requirements and when a goal proves to be impossible to achieve or a method inapplicable under the specific circumstances, the architect is expected to start thinking on entirely new lines. The last stage in the design process is the production of final drawings, but even then you may have to refine the specifications of the design. This may be a result of technical considerations or if, for some reason, you reconsider the goals of the design. A high degree of flexibility and capability to compromise without deteriorating the product quality is an indispensable part of the professional culture.

In the design process alternative solutions are looked for, analysed and compared in order to find the one meeting the goals in the most satisfactory manner. Therefore, one must ask "Does this alternative satisfy all the design criteria?" (Simon, 1982). The most effective method used by architects in the search of applicable alternatives is sketching. A sketching is used to visualise an idea of a possible design solution and evaluate it before it is formalised. Even a very diffusely defined idea at the initial stage of the design process can be expressed and communicated by the architect. Although the impression created is a general one the other part will be able to comprehend the idea behind it. The secret of sketching is the use of an "undetermined representation of the building" (Lundequist and Kjelldahl, 1989) as opposed to e. g. the very concrete representation used when producing the final drawing of a plan. It is very important to note that one sketches in all stages of the design process, not only in the beginning. A typical scenario is to discover a conflict between the design goals and corresponding design solutions concerning the detailing in a late stage of the design process. To solve those kinds of problems one has to return to sketching as it is a method not only of finding a solution to a problem, but also of re-examining the goals of the design in question. This example also points to the fact that design is not a sequential process. It is rather a process in which different symbolic systems responding to the current issue are implemented in order to reach a synthesis in the final design.

Design is a process of exploratory search where a number of alternatives is hypothesised and their effects are predicted and evaluated (Carrara, Kalay, et al., 1992). Very often conflicting issues are been dealt with while searching for a satisfactory solution. Since goals are diffuse in the beginning of the design process an architect has to rely on knowledge and experiences as well as on information relevant to a specific project. The knowledge encompasses one's own past experiences, outlook, judgement, aesthetical values, preferences and feelings as well as validated professional knowledge and practices. After some years as a professional designer one has created a set of design solutions and learnt how to use them in different situations. For example if one works with architectural detailing, the different solutions represent his knowledge of detailing in architecture. This is to say that the process of acquiring knowledge and the process of design are, within this context, different perspectives of the same process.

Another essential part of the architect's professional skills is the ability to use models. The concept of modelling and the use of models may be very complex in the conceptual and theoretical sense but praxis develops at least a professional understanding of the use of models in building design. In fact an important part of

the educational training of architecture students is learning how to work with different models of buildings.

A very significant aspect of the design process is the search for a detailed resolution of the many different problems and the integration of design solutions by different members of the design team. This collaboration between the architect and the other consults on a construction project implies an ability to understand and to make oneself understood. A great amount of information is produced and delivered during all stages of the design process and effective communication between all involved facilitates the exchange, selection, storing and reuse of information of value to the project.

Designers use an abstraction hierarchy in the design of an artefact. In the hierarchy used in building design the building itself and the main systems of the building are found on the higher levels, and the parts and details on the lower levels. One will notice that within this hierarchy the design process is not sequential although it is normally started on the higher levels. Once engaged in the design process one does not proceed in a linear fashion but rather moves freely between levels. It is from the different levels of the design process that the architect must be able to find, retrieve and use design solutions resolved in earlier designs.

An issue of interest is the way an architect refers to various phenomena in his praxis when searching for and using different types of information. We think that one refers to buildings and sketches, drawings, photos etc. representing them as well as the projects for the design of these buildings. The references should not be limited to one's own designs - all buildings as a whole form a wide reference frame. This affluence of information calls for a lot of consideration when discussing possible structures for the Kit of d. p..

In a design profession the knowledge through experience into new designs is an essential part of the professional knowledge. Considerations based on experience are not only important to the final result at the time of the construction of the building, but are also of great importance to the future use, the cost of maintenance of the building and rebuilding that will most likely take place. Thus, an mportant input in design is experience from other projects. In practice this means that design solutions are very often reused from one project to another. The word "reuse" indicates that either you can use a copy of your earlier work as it is or use it as a prototype for further development and adaptation to the new design. It is not unusual that architects develop a personal set of tested design solutions which may be called a Kit of d. p.. The Kit of d. p. is a very important part of the individual professional knowledge as well as a part of the culture of the office and in a broader sense the culture of the profession.

According to our experience the CAD systems today provide a limited support in the process of finding, retrieving and reusing design solutions from previous projects into new ones. In respect to architectural work this becomes a serious drawback mainly because it hampers the implementation of experience into new designs. We believe that an important benefit of Information Technology in construction industry includes the increased possibility of reusing design solutions. This is a reason why we interpret the present changes in the construction industry as a strong support for the further development of the concept of a computer organised Kit of d. p. into a valuable tool answering to the future needs of the architectural office.

2. AN OUTLINE FOR A KIT OF DESIGN PARTS

2.1 THE INFORMATION CONTAINED IN THE KIT

The metaphor used while discussing the contents of the Kit of d. p. is the project archive of the architect's office. The Kit of d. p. was originally meant as a tool to store technical solutions. The term "technical solutions" is used in a broad sense meaning the solutions used by the architect when dealing with aesthetical and spatial issues and the system design that are vital to the final result of the design process.

However, the work has shown that the Kit actually should contain information relating to three different stages of the projects within the office. The basic function is to provide a Kit of d. p., that is a database containing information that has been validated according to e. g. a quality program within the office or some other kind of validating process. Apart from the kit part of the database we use it as an archive where you can store all projects carried out at the office and finally we can use the Kit as a database with information on projects in progress. Also, the Kit may contain information imported from external databases or relations to external databases. An example might be CAD drawings published by a manufacturer of components. The status of the information is reflected in the status object which has restricted admission allowing only selected people to change the information.

Also, we can look at the information from the point of view of the person or organisation controlling and/or owning the information. This is a difficult problem since the procedures used in practice and the legislation are still immature with respect to the new demands raised by the use of information technology. The main owner of the information is the architects office. As for the information concerning the projects in progress it will likely become a property of the client. The control over the information stored in the Kit must be part of the management of the architects office and the same goes for the information in the archive and current projects. However, it is important that each architect has a part of the database which he can control himself, e. g. to build a kit of his own. In all, the issues concerning the control and ownership of the information are very difficult to master in as much as the copyright legislation in itself is difficult to handle.

Technical solutions are represented as digital drawings, descriptions, manufacturer's information, photos of tested details, records following up previous construction solutions. The user searches information by project name, product category/type, a search system/directory or one or several combinations of the above. The search system is based partly on the BSAB- system and partly on a key-word structure with the possibility to add own key-words.

Since spatial issues are the essence of an architect's work it is a matter of course that the Kit of d. p. shall be used to store information about them. The most usual representation form is the digital drawing but scanned photos and sketches and video could be stored as well. Graphical information could also be directly generated from a 3D CAD-model of the project or a product model. Different representation forms serve different purposes and the user should decide himself in what forms the information is to be saved depending on his specific needs. In all, this means that there are many kinds of information and many views on the information in the Kit of d. p., each view representing a specific situation with respect to the status of the information.

The strategy behind the development of the Kit is to start with a simple system comprising these elements. In the next step the Kit is to be integrated into a system of Project Wide Databases. The latter system includes a case-based
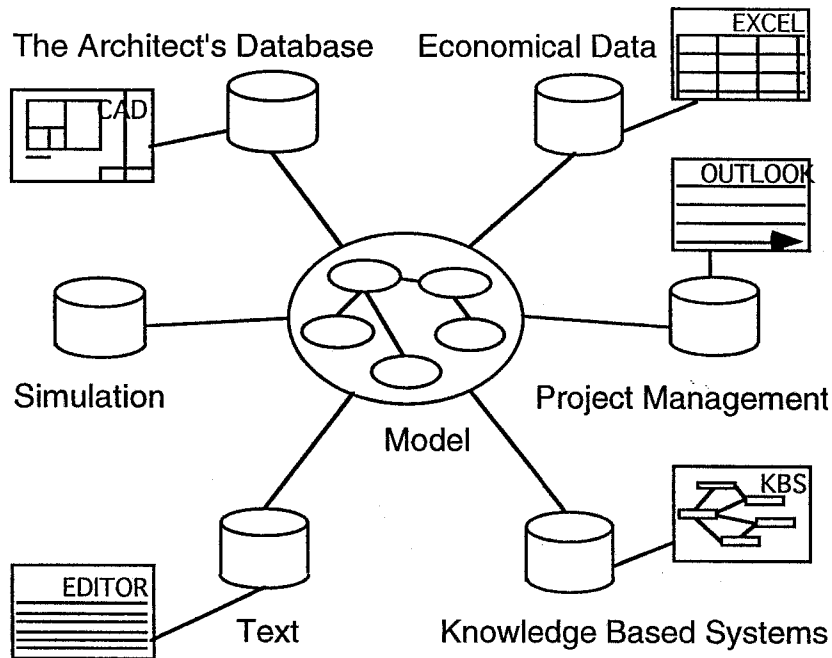

Figure 1. The concept of Project Wide Databases

reasoning system and a semantic network that will help the user to navigate the various databases.

In our work on a concept for The Kit of d. p. we have tried to embrace all of the above mentioned aspects of design knowledge and praxis. The conclusions we can draw from this short discussion about the design process are that we need a flexible method with regard to the searching within the hierarchy and the presentation of the results. The system must be able to present the results of the find and retrieve actions in a way that is appropriate to the present needs of the designer.

2.2 A MODEL OF THE KIT OF D. P.

The Kit of d. p. has been modelled starting out from the working situation of the architect and the kind of references he uses. At present we have made some restrictions with respect to the usage of the Kit, the most important being that it is intended primarily for building design. However, it should be possible to further develop the model to make relations e. g. to information needed in planning and to GIS-systems. Another restriction is that the relations to present classification systems used in construction industry have not yet been documented in detail. The model has been developed in line with the conclusion that product models have to be developed as systems of models consisting of e. g. a data model, a product model, a generic building product model and an aspect model to fit the various needs (Björk, 1993). Making a simple comparison the Kit is intended to be like a hub to which you can attach all kinds of information and information structures. The model of the Kit has been documented using EXPRESS-G.

The references have been gathered in three groups that are used as main objects or entities forming the Kit of d. p.: building_or_part_of_building, representation and
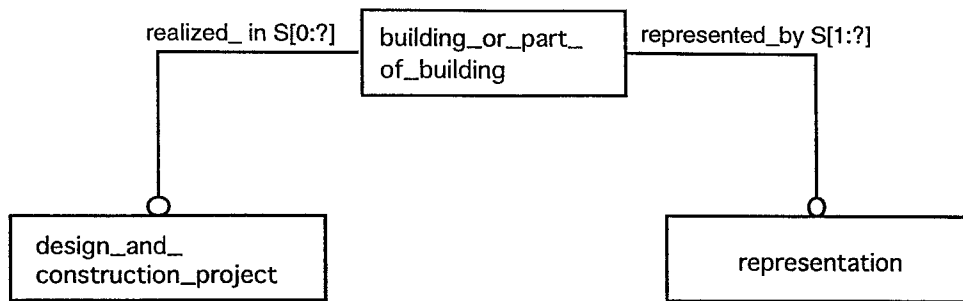
Figure 2. Basic structure of the Kit of d. p..

design_and_construction_project as illustrated in figure 2.

Usually buildings or parts of buildings are main objects for the architect's work although many architects of today carry out more of other kinds of design projects. This problem could be simply taken care of by making a supertype of the building_or_part_of_building object called design_object as we can se in figure 3. Now we can add other kinds of design objects to meet future needs.
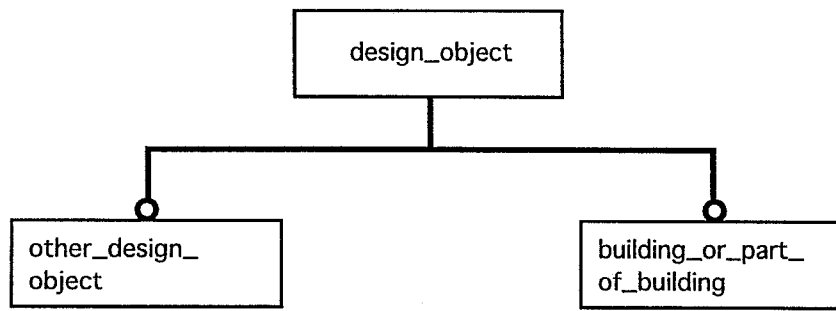

Figure 3. An extension of the kit allowing other design objects than buildings or parts of buildings.

Most of the work in the architect's office is organised in project form and projects are often referred to in the discussion about the work carried out. Thus we have added the object design_and_construction_project to the Kit giving us the possibility to search information referring to the projects in which the designs have been realised.

The third main object is **representation**. By representation we mean all kinds of models and documents that are used to describe the building during design, construction and use. As of today drawings is still the most important representation and we believe that it is very difficult to predict what kind of representation the industry will rely on in the future. Other important representations are different kinds of text such as names, addresses, descriptions and bills of materials. Different kinds of calculations and cost estimates are other kinds of representations that are essential for the construction process. From the architect's point of view different kinds of pictures are an everyday representation. They include sketches, water-colours, photos, 3D renderings and moving pictures such as animations and digital video.

The main objects of the Kit of d. p. have been modelled in further detail to document the proposed structure of the Kit. First we will have a look at the information connected to the building_or_part_of_building (figure 4).
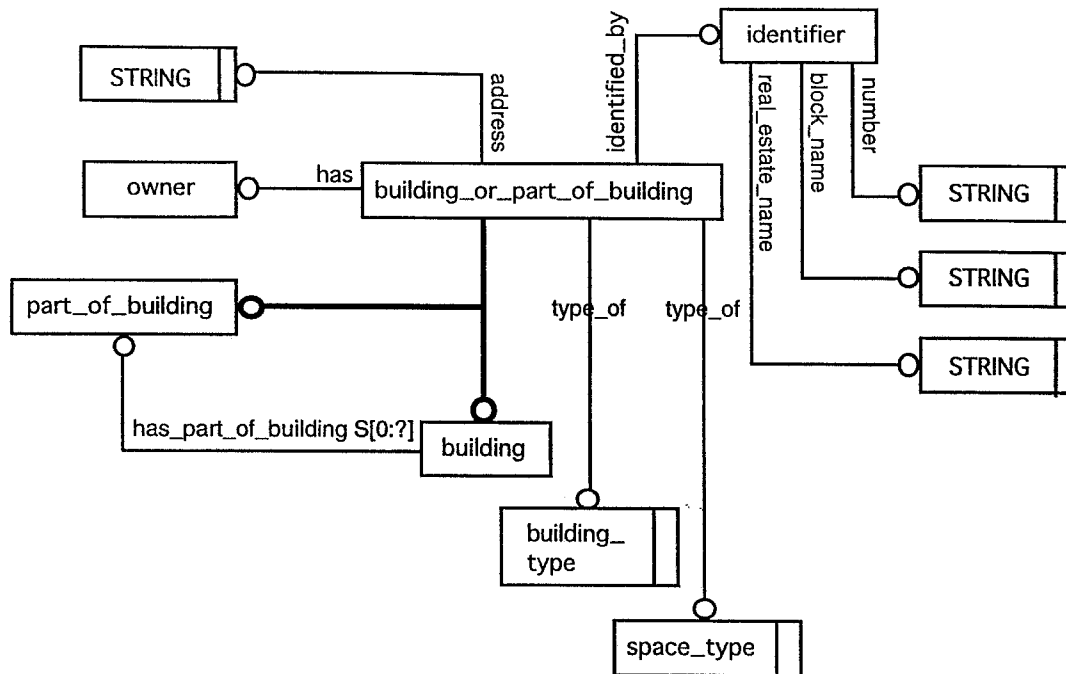
Figure 4. Model of the design object.

2.2.1 The building_or_part_of_building

When we look at the building_or_part_of_building at the first level of abstraction from the point of view of the Kit of d. p. the main purpose is to give it an identity and to characterise the building. The identity is defined by the names of the real estate and the block and by a unique number of the houses within the area defined by the same names. This may change since there is a proposal for a Swedish nation-wide base register covering buildings. The proposal has been published by CFD (Centralnämnden för fastighetsdata, 1991) and when this register is introduced it is likely that it will establish a method to give unique identities to buildings. In this part of the Kit we also put information about the owner of the building and the address.

In order to characterise the building we use a classification system to identify different types of buildings and spaces. The system proposed by the ISO/TC59/SG13 project on common structures for grouping information concerning buildings and spaces is relevant to the needs. The aim/use of buildings and spaces is used as grouping criterion and the proposal comprises a classification of Building types and Spaces (Building Elementary Spaces).

Also, the design object may be a part of a building and thus the entity is described as building_or_part_of_building having the subtypes building and part_of_building.

2.2.2 Representation

The object representation is subtyped in the various types of representations used in design, construction and use of buildings according to figure 5.

Drawings are still the most important representation of buildings during design and construction. CAD drawings amount to a mere part of the numbers of drawings but there are still huge amounts of paper drawings in use and in different kinds of archives. Thus we have to take care of these paper documents in

the Kit of d. p.. Regardless of the kind of drawing each drawing is identified by a drawing number. Also, we should give each drawing a raster copy for the purpose of quick browsing of the database. This is also for security reasons when distributing information among large groups of consultants. Old drawings that are now in ordinary archives do not need to be digitised until you need them e g. when starting a rebuilding project. Moreover, each paper document in the Kit has data about the location and CAD drawings have information on file name and file format related to the drawing. The modelling of the drawing object is influenced
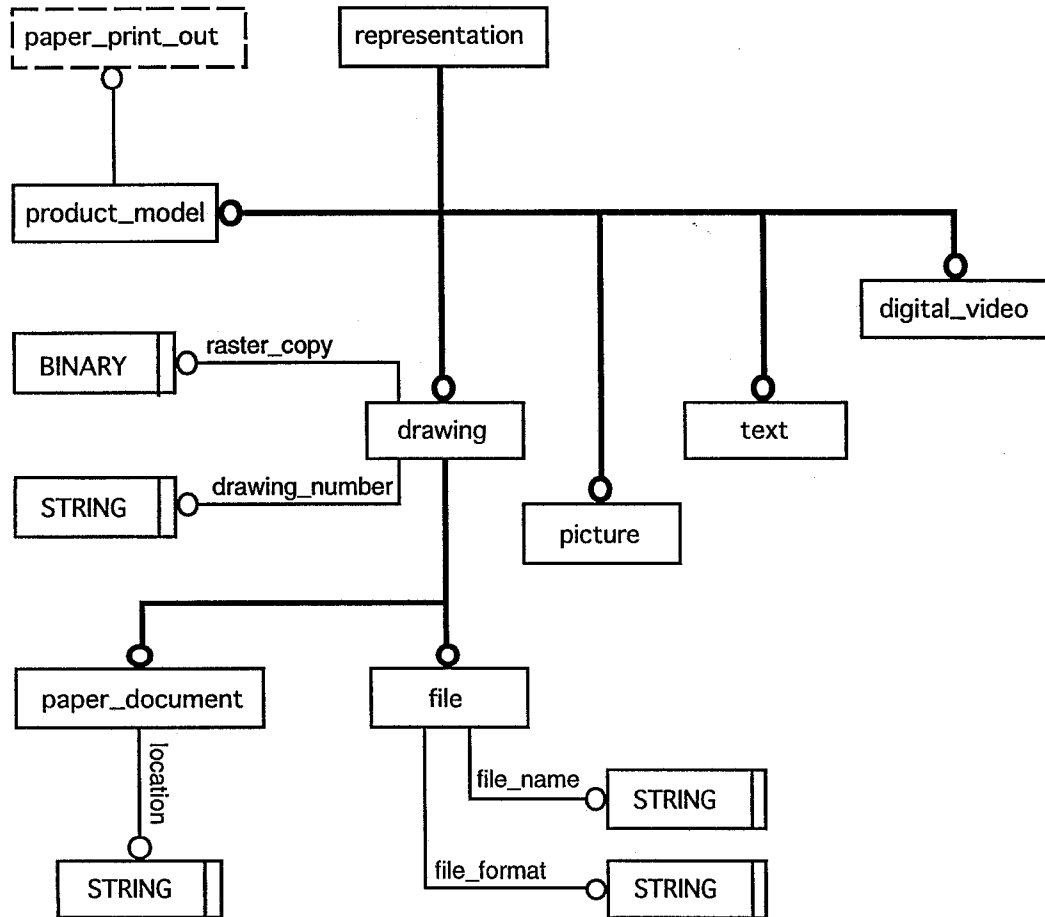
Figure 5. Model of representations used in design, construction and use of buildings.
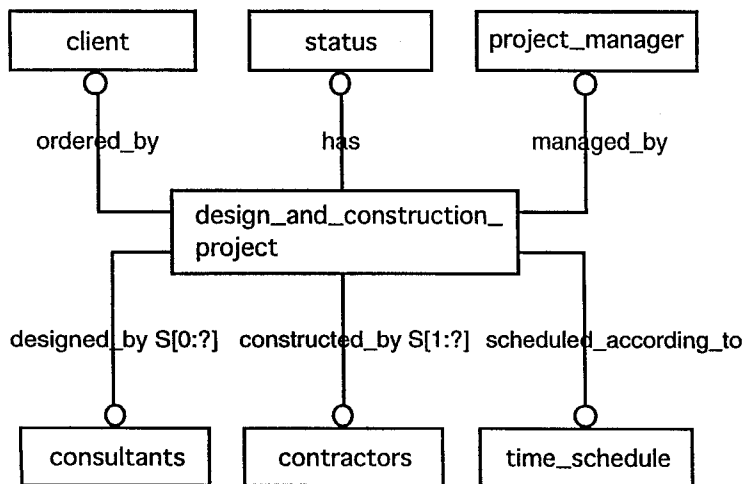
Figure 6. Model of project information
by a study on Integrated Construction Project Document Management carried out
by Björk (Björk, Huovila et al., 1993).

2.2.3 Project

The information related to the project is used mainly to search the Kit with
referens to time, type of contract, participants in the design team, contractor etc
(figure 6). An important object related to project is status, which is used to
identify the information as part of a current project, an archived project or the Kit
and the owner of the information.

3. THE KIT OF D. P., A MULTIMEDIA INFORMATION SYSTEM

The ideas regarding the design of the interface of the Kit of d. p. has been
influenced by the development of multimedia information systems. Multimedia
has matured as a concept and points to a wide area of useful methods to integrate,
query and use all kinds of data and as we have seen from the previous discussion
the Kit will comprise all kinds of data from simple text to digital video.

When designing the interface to the Kit we use the everyday tools in architectural
work as a metaphor and these tools have been analysed as part of the background
study to identify the requirements for a design tool. It is developed as part of a
prototype development which also includes CAD software, a database and
communication tools.

3.1 REQUIREMENTS FOR A DESIGN TOOL

Designing a tool for architectural design is a creative and "evolving, shared
process requiring prototyping, developing and evaluating (Coyne, 1992). We have
tried to consider the most fundamental requirements for a design tool that will
support the everyday work in the architect's office. A tool should feel comfortable
to use: besides high technological performance the users need a sense of
familiarity about the way it functions. One way to achieve this might be the
implementation of metaphors thus contributing to a more natural human-
computer interaction. The concept of Kit of d. p. is based on the design
knowledge, the experiences and the routines of the architect (his professional
culture). "... Particular metaphors emerge from our experience... Metaphors are
part of shared experience and become dominant in a community" (Coyne, 1992).
The archive of the architect's office has been chosen as an organisational
metaphor representing the structure of the Kit.

In a construction project a great amount of information is generated, acquired,
processed, structured and stored. The Kit of d. p. as a tool ought to provide
accuracy in communication between the user and the machine and between the
different users. It should also enable the architect to filter and select the kind of
information needed from all stages of the design process. Since design is a
dynamic process and a building design problem is defined gradually as the project
proceeds, a design tool should be flexible enough to adapt to the changes and the
emerging new conditions.

We would like to regard the architect's design knowledge both as a requirement
and as a tool in realising a concept. Besides the human brain, computers are the
only devices capable of symbolic representation of information. Hence, the tools

in the field of computer-aided design for representing professional knowledge and supporting the design process should be further developed. Design knowledge comprises three distinct, yet related, modalities (Carrara, G., Y. Kalay, et al., 1992):

1. Descriptive knowledge, representing the objects (and concepts) comprising a particular domain of design.
2. Normative knowledge, representing the goals (intents) to be achieved by a particular design project.
3. Operational knowledge, representing the methods (strategies) to meet the specified goals.

Since these different modalities are interrelated and an architect uses each one in his everyday work, we think that the Kit of d. p. ought to be able to support all of them.

3.2 USING MULTIMEDIA TO INTEGRATE INFORMATION AND PEOPLE

Multimedia represents the ultimate use of computers in the sense that by using multimedia technology we can use all kinds of data in the computer. Multimedia has developed in at least three directions, each representing a characteristic way of using computers. Computer games represents a huge experience in using a mixture of different electronic media and are closely related to the use of computers in cinema and TV etc. An other direction is the use of computers in training and education. Here we notice a very strong development merging to an ever increasing extent into new areas.

In the areas of multimedia that we have discussed so far we use multimedia applications and desktop systems. If we add networking as a third component we have established a system that can be used as a powerful communication system for people working in teams. You can call it virtual design teams.

A Multimedia Information System "is a repository for all types of information object. In the computing context, this means all types of digitally representable data such as text, images and voice." (O'Docherty and Daskalakis, 1991). The main database vendors provide multimedia server capabilities. We can expect that these capabilities will be further developed in the near future especially in conjunction with object-oriented databases. Also, a lot of research is going on in this field and O'Docherty and Daskalakis gives a broad overview of some prototypes of multimedia information systems and discusses some key issues concerning i. e. queering on the basis of semantic content (O'Docherty and Daskalakis, 1991)

Integrating e. g. computers, telephones and fax machines over a network turn the computer into a communication centre with substantially more capabilities than the separate units. Also, the development of the infrastructure needed is very fast and high speed modems, ISDN, ATM and fibre optics promote the acceleration. You can say, finally, that today we have brought about a radical change in the time and space organisation of work and really the intriguing question is what effects this will cause the organisations. In all, we can expect that the use of multimedia technology will give us better access to the ever increasing amounts of information of all kinds that will become part of the future design process.

3.3 A FEW COMMENTS ON USING THE KIT OF D. P.

The Kit of d. p. is intended to be used as a design tool primarily for architects. Also, the intention is to build a simple system with respect to the components in use as well as the interaction of the user. The most important part of the Kit from

the user's point of view is the interface that we consider should be developed as a general interface for a design tool designed according to the guidelines for graphical user interfaces of today. This means that it should be possible to reach the different tools you need from one place.

Searching the database will in the first stage be done using SQL queries and browsing. SQL queries are restricted to structured information and will not meet all needs when searching the database. On the other hand SQL is a standard that will continue to develop and of course we should use it whenever suitable.

Browsing a database containing large amounts of graphical information is a broadly used way of searching information. Often browsing is used in conjunction with SQL queering to limit the range of information to be browsed. We hope to be able to develop more sophisticated ways of searching information in the database. This problem is discussed among others by O'Docherty and Daskalakis (O'Docherty and Daskalakis, 1991) who points to the use of semantic networks as an interesting method that will allow content based retrieval.

Storing information in the database is carried out in different ways depending on the situation. As we have discussed the information in the database is three different categories. The kit function implies that the information has been validated before it is stored in the database. The basic idea is that first we design, then we define the objects to be stored in the database and finally the objects are stored in the database. In other words there is no automatic process to store single objects in the Kit of d. p.. The process of defining design parts within a CAD model is similar to the methods proposed by Fruchter et. al. (Fruchter, Clayton et al., 1993) where the designers share a common graphical model of the design as a communication medium.

However, when we start a new project and open new CAD drawings, they are automatically stored in the Kit and given a note that they are part of a current
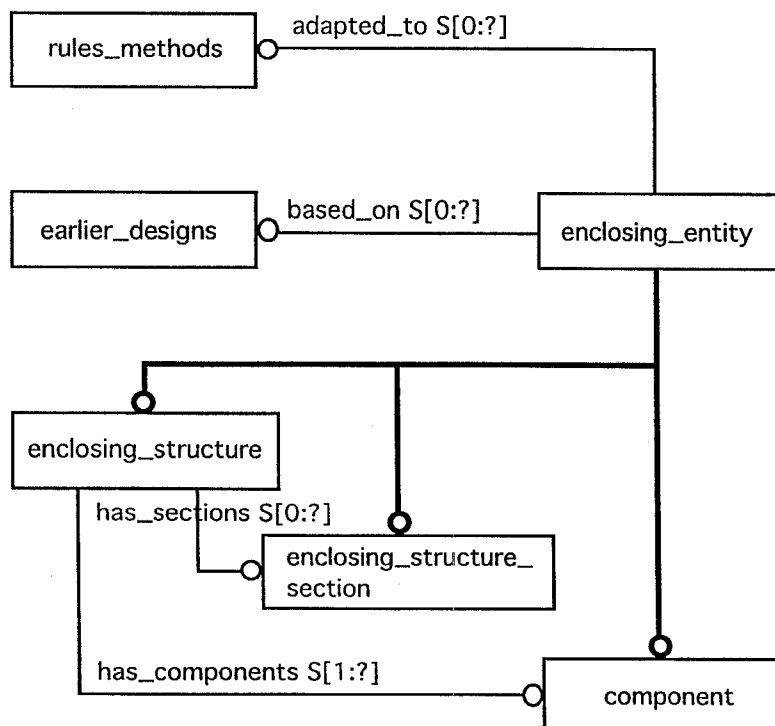
Figure 7. An example of the relation between design objects emerging in a new design and those of the Kit of d. p.
project. When the project is completed this note is changed to say that the information is part of the archive of projects that are carried out.

There are many ways to relate design objects emerging in a new design to those of the Kit of d. p. In figure 7 we have shown the relation between enclosing entities and earlier designs. Also, there is a possibility to relate the information in a new design to rules and methods in the Kit. The model of enclosing entity is borrowed from Björk (Björk, 1992).

For special purposes the architect needs information that is associated only to his profession. As an example we use information that is needed to make animations and simulations of interior lighting. This information may be related to a model of a new design as shown in figure 8. The model of space, space_boundary and space_assembly is borrowed from Björk (Björk, 1992).
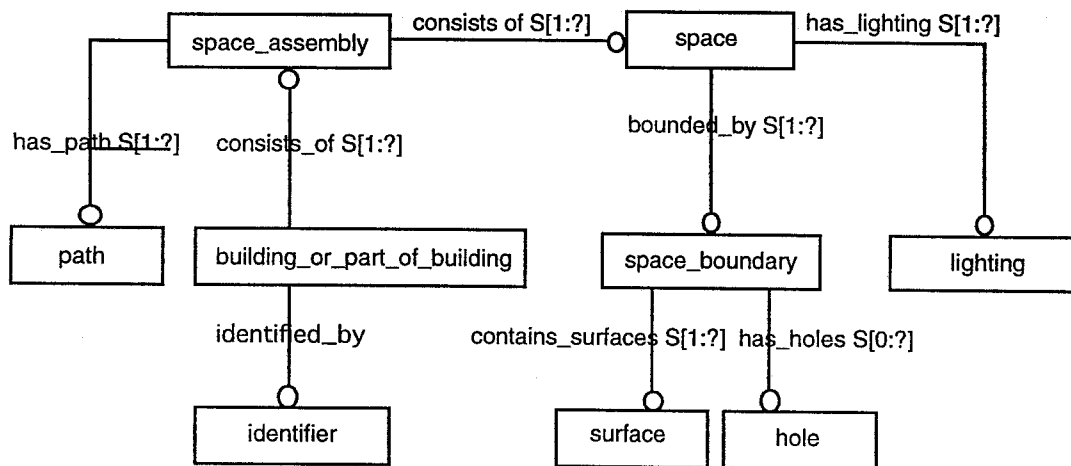
Figure 8. Information needed for animation and lighting simulation.

The information regarding path and lighting may be part of the architects database. The identifier object gives you information about the location of the building and once we know the location of the building information regarding the site, such as co-ordinates may be taken from a GIS system.

4. CONCLUSIONS

The work done so far has shown that it should be possible to build a useful database for the architect's office using simple methods and techniques. Also, we have seen that such a concept is open to further development using advanced techniques in the future. As of today the raise of computers in architectural design is largely growing in Sweden but the use is largely aimed at draft systems. On the other hand the experience of using computers calls for an advanced use where above all the possibilities to tackle the quality issues is focused.

In spite of the fact that the use of a Kit of d. p. will considerably change the way of using computers in the architect's office the mere challenge lies within the change of the design process as a whole. In the long run the advanced use of information regarding the various design issues will change the role of the architect in the construction process (Wikforss, 1994) and this will be one of the most important challenges facing the architect's profession during the years to come. We stated when we started this discussion on the Kit of d. p. that the

content of the kit was an expression of the culture of the architects office and now we can see that it will change not only the culture of the architects office but perhaps the culture of the construction process in itself.

Today significant changes that will support in the further development of the architects databases take place. The object-oriented environments develop as object-oriented databases emerge and object-oriented properties are been implemented into relational databases. We are most likely going to witness a standard for object-oriented databases developing soon. Advanced 3D-modelling and multimedia make a remarkable progress and gain ground in widely differing application fields. However, a question that we should raise is whether these new technologies are what architects can get or what they need in order to advance the quality issues in architecture.

Still, the most significant changes are probably the structural ones which, as it could be easily guessed, have emerged from the present crisis within the construction industry. Those changes are likely to imply a new project structure regarding volume, quantity, goals and locations . Besides the radical changes in the construction process, architects and other consults shall have to fulfil completely new requirements concerning documentation of work results and long-term responsibility, in other words quality assurance will be demanded (Wikforss, 1994).

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