The development of an architects oriented productmodel

ir.R. van Zutphen, ir. M. de Vries and Prof. ir. H. Wagter

Eindhoven University of Technology, Faculty of Architecture, section Calibre, P.O. Box 513, postvak 20, 5600 MB Eindhoven, The Netherlands

Abstract
In this paper various aspects of the developement and introduction of productmodels in the building industry are discussed. Management and design information are discussed more in depth.

1. Introduction

The term 'productmodel' is commonly used, and generally agreed upon. The main term in the word is 'model' and this word is mostly used to denote an example. The scientific meaning is more restricted. A model is a representation of relevant properties of an object that can be used to answer certain questions about that object. This definition makes clear that there can not be a single model of an object. Models depend on their usage. In the case of productmodels the model is intended to be used to steer a production proces. It is very important to restrict the proces before attempting to define a productmodel. Otherwise it is difficult to decide which properties must not be included in the model and one can easily end up with a model that is much too large. Theoretically everything in the world may have its influence on the production process but such model would not be manageable of course.

1.1. Building Industry

If we limit ourselves to the building industry it is clear at first sight that the product is a building. The process for which a productmodel can be made is the construction of that building. Building-processes are specical in certain aspects when compared to other production processes. For instance the fact that the product is restricted to a single place and that therefor all means for the production (tools, materials and workers) must be moved to that place is very uncommon and can otherwise only be found in agriculture. In agriculture however the product is uniform whereas the building industry typically leads to unique products.
When one takes a closer look the building process appears to be slightly more difficult than we assumed before this. If we use as an example the phases the building process is divided in by the BNA [1] we get the following:
feasibility - brief - structural design - preliminary design - final design
contract and drawings - preparation - construction - usage
Further the awareness for environmental aspects increases. Today often the demolition of the building and disposal of the remainings is considered part of the building process. In the dutch situation many of these phases are performed by different participants in the building process. This is different from the situation in for instance Japan or the USA where large firms dominate the building industry. This fragmented organisation leads to many problems that can not always be clearly distinguished in other countries. The above mentioned differenti-

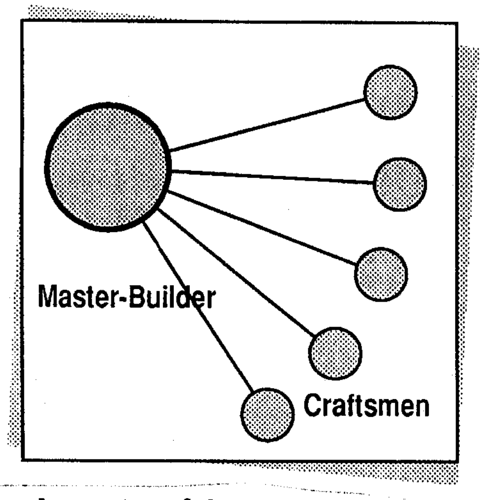
ation of the building process is obviously much broader than the rather restriced view of constructing buildings. In it three main processes can be distinguished: design, construction and use. These three partial processes are relatively independant from each other (there is of course a mutual influence) and are completed sequentially. It is difficult to define what the product of the 'use' process is. We will therefor not consider this process in this paper. The construction process has the most similarities with the kind of production for which the theories of productmodels have originally been defined. In the design process however the decisions are made that have the greatest impact on the entire process. For the rest of this paper we will concentrate mainly on this process.

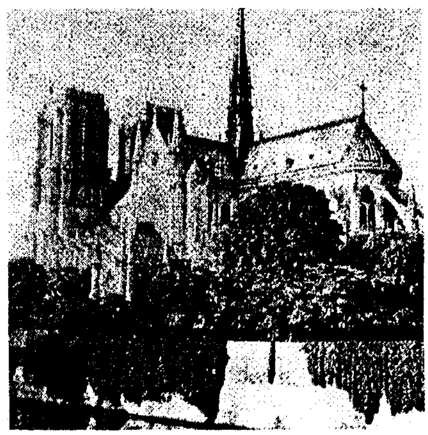
2. Historic developement

Before we start our discussion of the problems involved with the introduction and usage of productmodels we will give a brief overview of the devellopment of the building industry in (western) europe. This helps explain why this industry is organised as it is today, and why the various roles and participants are necessary.

2.1. pre-industrial (middle ages-ca. 1700)

In this period the building industry is organised, like all other industries, by 'craftsmen' and 'gilds'. De 'master-builder' was the main responsible. He deciced on the overall sizes and checked the work. He hired master-craftsmen who performed most of the construction. These masters themselves where primarily responsible for the quality of their own work.
There was little need for a elaborate design or communication. All participants involved had a clear idea what the finished building should be like and each was an expert in his own craft.



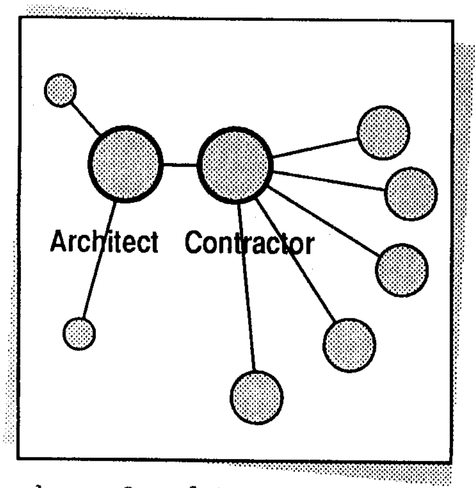


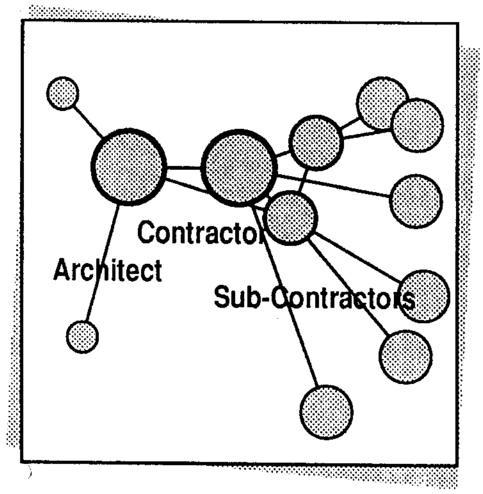
sheme1 and 2

2.2. Early Industrial (1700-1900)

This period is characterized by the gradual disappearing of the 'gilds'. The manufacturing changed to industry. Allthough building was not suited to be transformed to an industry it nevertheless was affected by the changes in society. Lack of craftsmen forced the builders to rely on less skilled laborers. This implied that more explanation was required and this led to a more dominant position for the

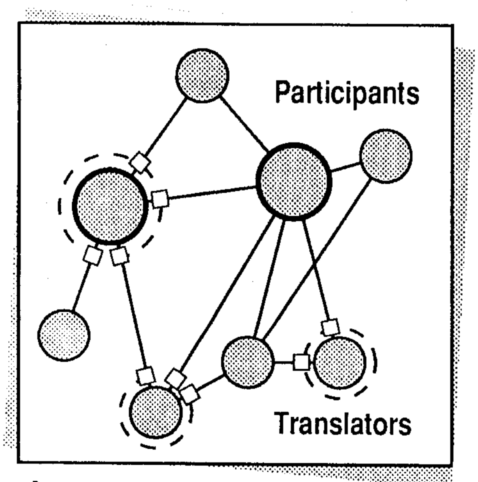
'design'. A second change was that more different types of buildings were develloped and that their overall size increased.
Because the social differences increased in this period the role of master-builder was split into a designer who defined and described a building for his usually wealthy customers and a contractor who hired laborers to build that design. Later sub-contractor hired laborers for special sorts of work.

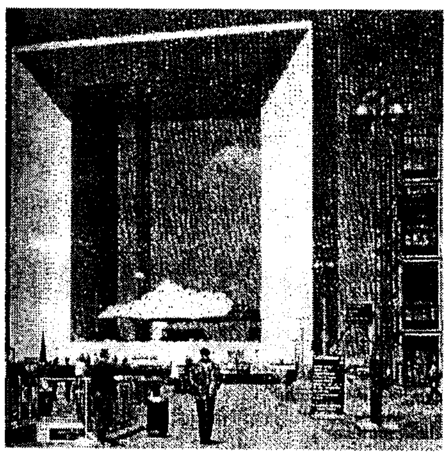




sheme 3 and 4

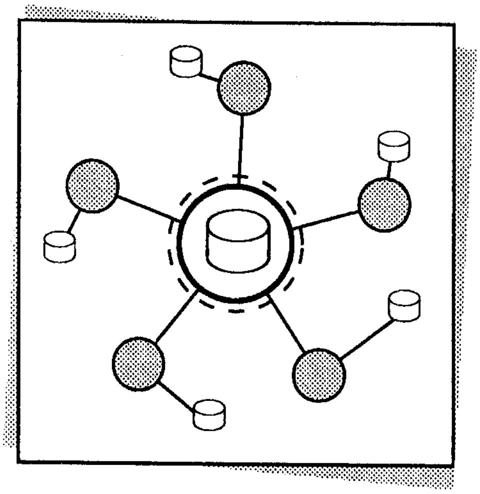
2.3. Industrial (1900-today)
The devellopment of industries was completed to a great extend at the beginning of this century. The ever increasing demand for buildings lead to a large industry of materials manufacturers. Attempts were made to change the building process into a more industrialized form (the Modern Movement). In the same period the technical possibilities increased tremendously. At this moment allmost anything that can be imagined can actually be built. All new technologies required its own specialists to ensure correct application.
The number of participants increased and the necessary amount of communication between them increased to. Some of the participants starterd to use computers for their own work and they would like to computerize communications as well. This usually leads to ad-hoc translations and in many cases communication is performed traditionally with drawings.





sheme 5 and 6

2.4. Future devellopment
It is clear that the changes to our society have their impact on the building industry and will continue to do so. It can be expected that in the near future the demand for improved communications increases. The current practice of incidental translators is unsatisfactory and will be discarded. Many people expect that communications by means of a general model of buildings will improve communication and that this is the role for productmodels in the building industry.



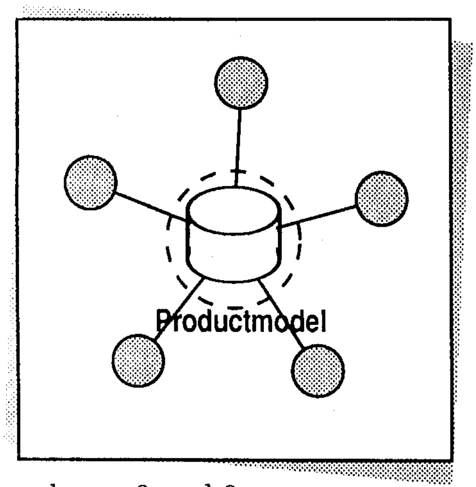
scheme 7

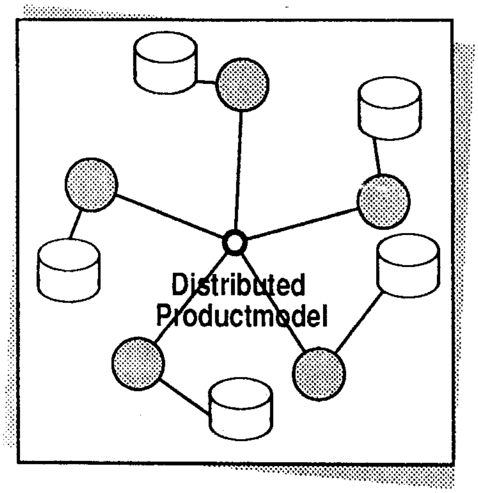
3. Importance of productmodelling

In a productmodel a complete description of a product must be made for all participants involved in the productionprocess. The information is required to be complete, consistent, unambiguous and immediately available. Not only geometrical information in drawings is needed but also for instance topological and functional information must be inluded in the model. Computerized access of the model is only possible if it is properly formalized.
Productmodels can help improve communication and allow cheaper andion flexible production. It is not yet clear how productmodels can be applied in the future. From the current situation two approaches are valid. The first is to create one central productmodel in which all information is collected and to which all participants must contribute their additions and modifications.
The second approach is to use a productmodel as an information exchange standard. Every participant maintains his own database but this can be accessed by the other participants via the productmodel.(see scheme 8 and 9)
When talking about defining productmodels there are three phases that must be clearly distinguished. First the 'development', second the 'introduction' and third the 'usage' of a productmodel. Every phase has its difficulties that will be discussed briefly.

3.1. Devellopment of a productmodel
In the firstplace a productmodel must be firmly rooted in a conceptual information scheme. This scheme can be independant from specific instantion of product information. Further the productmodel must be regarded in relation to the process it is intended to be used in.

In the second place must the techniques and procedures to obtain information must be standarized and structured. This is important if the model must be modified or expanded.
Lastly a the product model must be achievable, usuable and controllable. The model must be feasible both technical and financial. The model must fulfill the information requirements of its users and the model must be open enough to allow modificaton if the users needs changes.





scheme 8 and 9

3.2. Introduction of productmodels
It is clear that the introduction of the new information technology evolves slowly. Bemelmans [2] recognises four phases.
1: Initiation. 2: Diffusion. 3: Consolidation. 4: Integration.
It is important to realise that the various information systems within a firm are in different phases. Some systems are being initiated while others are already accepted and move toward integration. This diversity is often neglected by the management when they talk about integration. When a new system is introduced the management should in the first two phases stimulate and support it. Only in the last two phases they must define standards and regulations. If attempts to get to integration are made too early such project riscs failure and is likely to be expensive and overdue.
If we take a closer look at the building industry we find that at this moment most but the smallest architects offices in the Netherlands are in the consolidation phase. The contractors however are not realy automated yet. Less than 30% of the contractors with production under 50 milion is past the stage of stand alone PC's. It is given this situation senseless to talk about standarisation and integration in the building industry. One can not expect on short term that productmodels are introduced and used for communication between designer and contractor.

3.3. Usage of productmodels
There are many problems involved with the usage and maintenance of productmodels. These are out of scope of this paper as there is at this moment no operational productmodel.

3.4. Top down or bottom up?
In the Netherlands two main streams are emerging in the field of automation of the building industry. Their goal is the same namely to integrate the many loosely

connectedsystems and information streams that make up the building industry. Their approach to reach this goal is different.
A first group works in a top down fashion. It attempts to define an informationplan for the entire building industry. They claim that this is the only solution to the large amount of subsystems and translators. The 'reference model' they work on must be an integration related sub-models in which the structure of the information and the 'behaviour' is described completely and anambiguously.
The second group prefers a bottom up approach. This practical approach is likely to lead to usuable results sooner. The idea is to use available standards like DXF, EDIFACT or ISO/Step to connect systems as good as possible and to improv these standards. This practical approach should not be confused with the pragmatic 'weekend automation'. Those pragmatic initiatives lack a theoretical background and well defined goal that is certainly present in the EDIFACT or ISO/Step initiatives.
Both approaches have their advantages and disadvantages. Top down is a is a long term approach for which no short term pay back can be expected. It also requires that the participants have allready integrated their internal automation and that an accetance to cooperate with competing firms exists. The disadvantages of bottom up approaches are well known. It is different to reach a coherent system and small tuning problems will always remain. The decision on the approach must be made by the management and not by technicians.

4. Information management

A productmodel will finally be an integrated part of an information system. A good productmodel does not necesarily imply a good information system. There are many factors that make up the successsfull introduction and usage of productmodels. Bemelmans [2] recognises five parts. The informationmanagement, the architecture of the information system and the infrastructure of technique, information and organisation.
The technical infrastructure of an information system includes communal computer facilities etc. The organisational infrastructure is concerned mainly with functions in the field of information management. The architecture of the system is the application software that can be used with the information system. We will talk about management and infrastructure of information more in depth.
Many researches at for instance the TUE or TNO are involved primarily with the formal description of a conceptual model. They use a multitude of different scheming-techniques like NIAM [3], Entity Relationship, or the 'Hamburgermodel' [4]. Such model should lead to the development of a number of product models. They concentrate clearly on the infrastructure of information. This is, as said, only one of the five parts in the application of information systems. The other parts are equally important. If they are neglected the result can be nothing but disappointing.

4.1. Management

In an increasing number of companies information is considered to be a strategic resource. The management must plan which information must be maintained, just as the acquiring of new machinery must be planned. A mistake that is commonly made in decisions on automation is to look only at the needs of the end users. Software and appropriate hardware is selected according to those needs. At first glance this seems a sensible approach. There is a drawback however. The management should first decide on the strategic goals for the firm. This managementplan must be used to define an informationplan and system. If this is not done the automation will become fragmented, controlled by local forces. This will often be a computer enthousiast with no real experience in automation. This kind of 'weekend-automation' must not be taken serious.

4.2. Success factors

Goals for architects offices can for instance be to improve customer service, decrease cost or to improve quality. In many cases the availability of information is important to achieve these goals. There are other less obvious factors that are important for the success of an office. The choice for a certain architect is typically not based on price but on many other subjective criteria.

- Quality). In the building industry the 'craftsmanship' of the designer is often the most important factor to achieve quality. In buildings there are two different types of quality. The first is the technical quality This is the efficiency, amount and cost of maintenance, cost in use and so on. Cultural value is the second form of quality. The appreciation of a building by people certainly also depends on this quality.
- Style). Most designers use a recognisable style. For some principals a style may be the reason to choose a specific designer. This happened for instance at the new main office for the NMB in amsterdam (architect: Alberts)
- Fame). For some principals it is attractive to have a building designed by a famous architect. This is especially true if the principal wants to devellop a certain area in a city.
- Reliability). Many principals are novices in the building process. They must rely on the architect to guard their interests. The reliability of the architect is therefor very important.
- Regionality and relations). For many of the smaller projects it is convenient to choose a designer from the neighborhood. That designer has better connections with local government and contractors. This will most likely lead to less trouble with obtaining permits and with contractors. Furthermore there is less chance that a small design gets lost in the anonimity of a large architects office. The contact of an architect and principal is important too. The designer must find out what exactly the needs of the principal are. If this communication fails it is likely that the realised building is considered to be of poor quality.

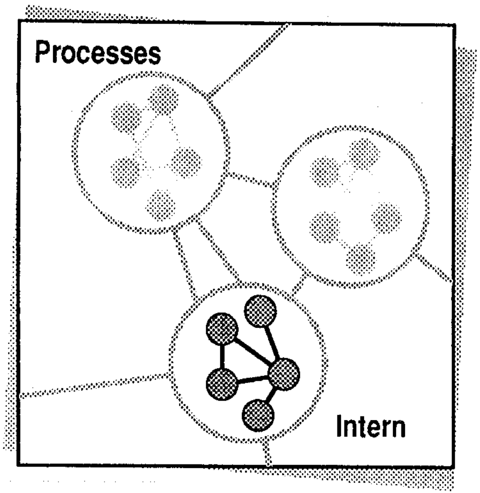
4.3. Application

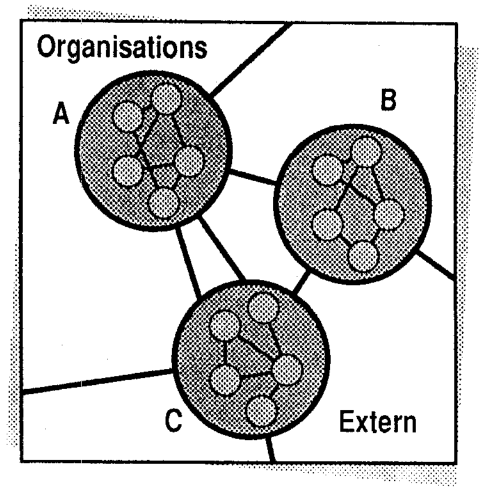
For some of the above mentioned criteria application of productmodels could lead to an improved position. It is commonly accepted that use of PDI will result in lower building and officecosts. It is also claimed that application of PDI must lead to improved quality as the risc of mistakes decreases. For an architect this can be reasons to start using PDI mainly for internal automation.

If we take a closer look there is less reason for enthousiasm. The first problem is that an office must make large investments to introduce PDI. It is doubtful if this investment will pay back. The reason for that doubt is that an office will benefit little from PDI. The advantage of lower building cost will be almost entirely for the principal. Another problem is that most principals do not care how a building is designed and are certainly not willing to pay for the application of PDI. Remains the idea that PDI will improve quality. Most problems occur because something is overlooked not because of some misunderstanding. Major improvements can not be expected in short term therefor. (see scheme 10)

4.4. Communication

This reason for using PDI is motivated externally. During the design process the designer must frequently exchange information with other participants, like technical specialists or a contractor. Application of PDI may have advantages here, since it is cheaper and more reliable. For small offices it is too expensive to start with PDI, and for them this is less relevant. Most large offices have already started office automation and will continue to devellop their information exchange. For these offices the application of PDI is a matter of service. Especially for the middle sized design firms PDI may become a critical factor to compete other offices.





scheme 10 and 11

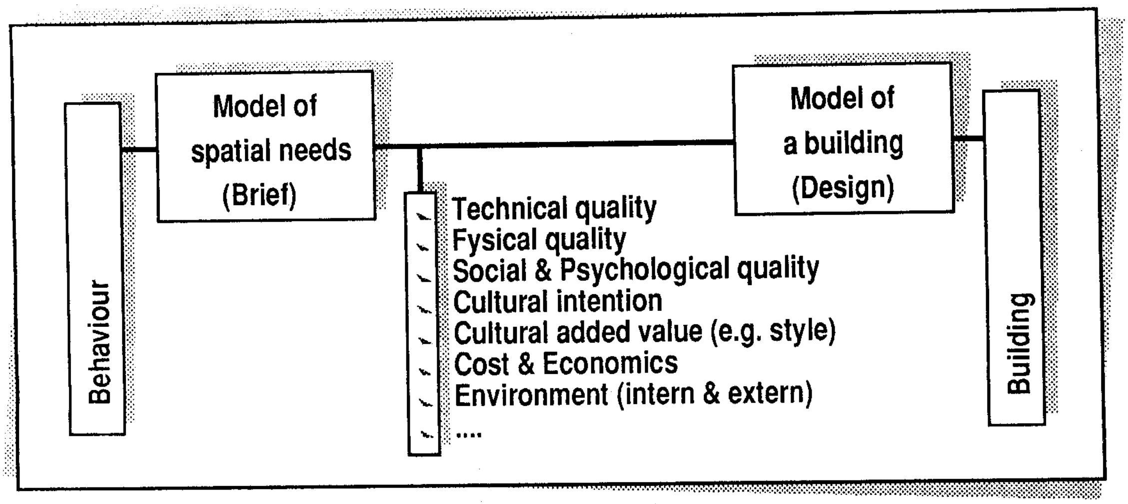
5. Design information

In three of the five aspects of the application of information systems there are problems likely to occur. There is little money available for the infrastructure of techniques. It is difficult to change the infrastructure of the organisation because many participants have interests in the prolonguation of the current situation. Especially architects have a strong position in the process and are unwilling to share their position with others. Both problems should be solved by management of information systems. The infrastructure of design information will also lead to serious problems. For approximately the last 25 years attempts have been made to formalize design information. So far this has not been successful.

5.1. Design

Most difficulties occur because of the specific nature of the design process. There are many definitions proposed amongst others by Mitchell [5], Simon [6] or Lawson [7]. They usually state that design involves the definition of a certain object or sometimes situation. The intention is to transform a certain unwanted state to a new preferable state. This definition is intentionally vague. It is easier to make a more explicit definition for specific types of design because there are many types of design.

In the case of architectural design the object to be designed is obviously a building. Burman and Saatela [8] explain that them meaning of designing buildings depends on culture to create specific buildings for specific behaviour. A building is in a sense a sort model for behaviour. Most of our behaviour is encoded in common terms like 'sleeping' and the environmental requirements for that behaviour are also encoded in rooms. At the start of a design process the designer tries to find out what behaviour (or functions) the principals wishes to be possible in the new building. The endproduct of the designprocess is a model of a building that meets the requirements. In that process many influences have to be accounted for.



scheme 12

A very important influence is the cultural impact on a building. Every building is, to a certain extent, considered to be a work of art. This idea dates at least from the greek and is today still valid. A building must be both practical and beautiful. All this, combined with the specific nature of buildings define the information that is needed to describe a building.

5.2. Nature of buildings

Buildings are composed of a large number of part organised in many systems and subsystems. All systems are highly integrated. Many parts are member of different and mostly independant systems at the same time. This kind of systems can not be modelled with simple techniques because circular references are likely to occur. In most cases design information is represented as hierarchical. In reality however this is only true for small and separate sub-systems. Larger combinations can never be described properly as a hierarchy. It is this organisation that is the main reason why it is difficult to design buildings.

Buildings typically differ from each other. In the first place because their locations differ which requires specific adjustments. In the second place because requirements are seldom identical. dn the third place because principals want their building to express their individuality. Effect of this is that series in the building industry are small. This hinders automation and optimalisations of the building process. Further there is less chance to learn from mistakes as the next project is always slightly different.

For every new project a new team of participants is assembled. For every new project new arrangements must be made. Not many principals build very often so they are inexperienced. This involves more work for either his advisor or the designer and can easily lead to misunderstandings.

The majority of the projects is relatively small. Typically 100 to 2000 m2. In projects of this size there is usually little time and money available. There is little opportunity for experimentation and the actual design takes relative more time. It is difficult to use computer tools for information management in this situation.

The number of parts in a single building is so large that this becomes a serious threat to the feasibility of productmodels for the building industry. Old estimations for the size of a description of a sky scraper talked about few hundreds of kilobytes. Today a drawing of a single floor of that skyskraper may exceed that size. In those drawings no property information is included and no relation is stored along with the drawing. If a model becomes too big it will be too expensive to fill it with data and to manage the model.

5.3. Nature of design

The complexity of buildings and the limitations of human reasoning and memory define to a large extend the way architects design buildings. It is impossible to maintain a single representation of a building. Instead a designer uses many different representation simultaneous. Each representation shows different systems, and not all parts must actually be tied to real objects. A representation is made according to the current state of the design and to fulfill specific needs. It can not be defined beforehand.

An additional difficulty is the fact that during a considerable part of the design process the designer uses imprecise information. Design is mainly a process of heuristics and trial-and-error. The accuracy of design information depends on the current representation. During the designprocess the design is likely to be changed considerable. There are currently no modelling techniques that can cope with these characteristics in a consistent and easy way.

6. Conclusion

The developement of the building industry shows an increasing need for communication between an increasing number of participants. Productmodels can be used to improve this communication. The development and introduction of productmodels, based upon an information system involves more than just 'data modelling'. Especially organisation and management play an important role. In present initiatives to develop a productmodel for the building industry these are often neglected. Many aspects that are relevant to the introduction of inforamtion systems in the design process are difficult to quantify. Because of the organisation of the building industry little support can be expected.

The nature of buildings and of the design process are difficult to describe formally with currently available tools and techniques. More research is needed in this field.

Te introduction of large scale productmodels can not be expected in the near future. There are too many theoretical and organisational problems that have to be solved beforehand. This is especially true for the more ambitious large scale projects concerning the entire building industry. On the otherehand the developement of small scale productmodels for subsystems is more feasible. The developement of these models can serve as a pilot project for the larger productmodels.

References

[1] W.J.M. Welling e.a., Informatie verwerking tijdens het bouwproces (dutch), BNA (=union of dutch architects), 1984

[2] T.M.A. Bemelmans, Bestuurlijke informatiesystemen en automatisering (dutch), Stenfert Kroesse, 1988.

[3] G.M. Nijssen and T.A. Halpin, Conceptual scheme and relational database design, Prentice-Hall, 1989

[4] F.Tolman, W. Gieling e.a. Four years research of product modelling, collected papers, TNO IB-BC, 1989

[5] W.J. Mitchell, Computer aided architectural design, Petrocelli Charter, 1977

[6] H.A. Simon, Sciences of the artificial, MIT press, 1981

[7] B. Lawson, How designers think, Butterworth arch., 1990

[8] C. Burman and S. Saatela, Describing man-made structures, research notes 1240, Technical research centre of finland (VTT), 1991