Coherency and Automation of the Design Process Applied in CAD Systems

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The article discusses a few postulates concerning the desirable structure of design data base with the aim of allowing the concurrent work in the design process. It depicts the problems of simultaneous access to the data base, and discusses the problems of redundancy of design information and their consequences in the structure of the design data base. Finally, a few examples of CAD systems are examined in order to find out how they deal with the problems of design partitioning and keeping it automatically coherent as well as some educational remarks are formulated.

1. Introduction

The objective of the design work is to generate a set of information which is complete, coherent and readable which represents a particular physical object. This information is put together in order to construct the object in some way. The postulate of readability can be attained thanks to the respecting of the normally accepted graphical representation such as conventional sections or views. The completeness is the matter of time and designer's skills. Let me focus then on the third component, the coherency.

2. Coherency in the design process

One of the challenges in design development is to keep it coherent. Traditionally, the consciousness of the designer keeps the design coherent. Such a task is rather easily fulfilled when applied to a small and simple project while all the design work is done by a single designer. It becomes, however, extremely complex when the design is developed concurrently by a team of different persons. Moreover, such a task becomes almost out of control when the design is made in the computerised environment. I would like to discuss a specification of such a multi agent design environment.

2.1. Traditional scheme of work process

Let me start with an analysis of traditionally functioning systems in which the coherency of the design consists in the observance of the rules agreed by the co-operating work group. In such situation different parts of the design are split into individual drawing boards and regular meetings of all members of the group as well as bilateral contacts enable a co-ordination of the concurrent work. As a result of the consecutive meetings a set of rules is formulated, which each member of the group should voluntarily and consciously follow.

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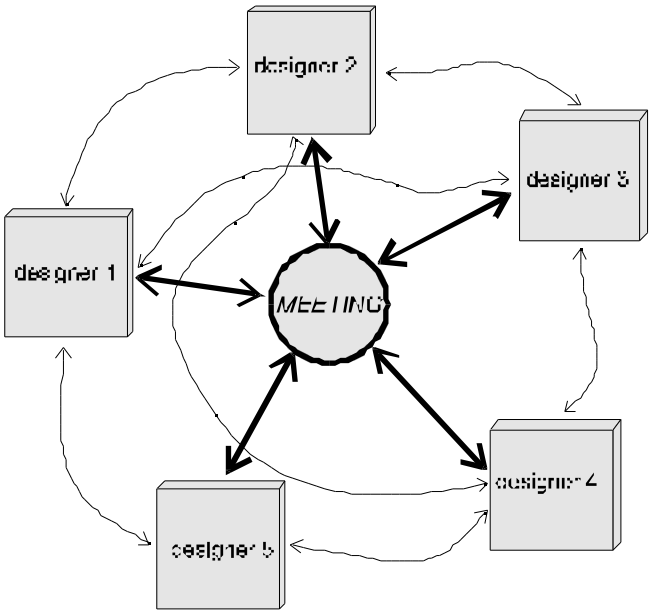
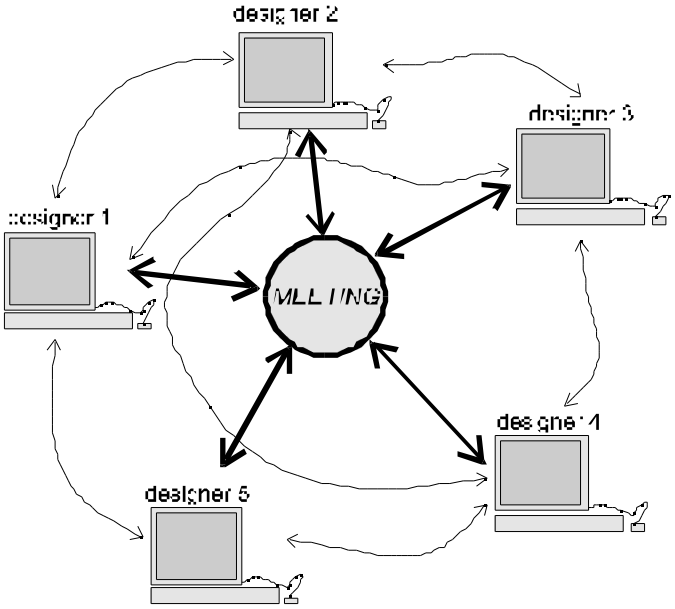


1. Traditional scheme of work and flow of information

In an idyllic situation (in an isolated structure) such agreement might have function but in the real life the design development proceeds under external influences and pressures which disturb the prior stated clear rules. To keep such system function, a certain amount of self-discipline is necessary although it seems possible to accomplish the goal.

2.2. Traditional scheme vs. computerised environment

As one takes the traditional scheme and tries to embody it into the computerised environment, the existing problems rise and the new ones appear. As an example let me focus on the ability of modification, which is typical of computerised drawing. A modification on paper requires certain effort, is time consuming and is rather irreversible; these three concerns prevent the design from being too spontaneously modified, that is, without deeper reflection on this modification's consequences. In computerised drawing the ease of change, which is generally regarded as an advantage, actually generates additional complexity to the management of design development. As modification might be easily made, a common error is committed by the designers: it is instantly embodied into the design, most often with minimal co-ordination with other designers from the team. A psychological aspect starts playing its role, if something is so simple and reversible, so it should not have heavy consequences. This is a trap because even apparently simple modification almost always has its consequences affecting in the whole design. The foundation of the described scheme is based on human to human communication. The correctness of the flow of information consists only in the human factor. Computers, offering their flexibility, influence much more the design process than any other tool, as a result, an increased amount of effort must be made in order to keep the process run coherently. In such a way apparently good organisational rules are abandoned because the effort directed on keeping them function, overpasses the productive work itself. It seems worth considering the development of automatic devices which can play active role in the structure.



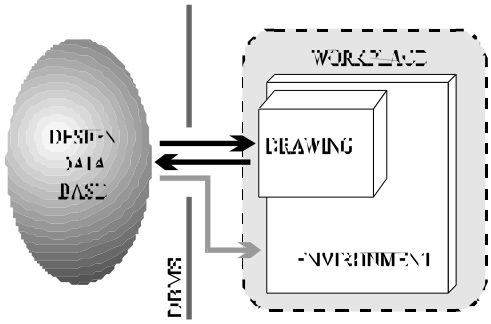
2. Directly transferred traditional scheme into computerised environment

2.3. Computerised process

A new organisational scheme must be developed which will attribute an active role to the computer in the co-ordination of the design process. My proposal for such scheme consists in Data Base Management Systems. The object of the scheme is to represent work organisation appropriate for the concurrent work process. It is a process in which all involved agents simultaneously and mutually influence the actions of other designers in the negotiable manner. The DBMS should play the role of "on-line guard" which can help in keeping the coherency of the design. Let me introduce some terms which might be helpful in the description of the work scheme. The whole information concerning the design and the information's relations should be stocked in a single data base. The designers can work on temporarily delimited buffers of work and such entity I call the workplace. What is specific for design and different from other types of data bases, is that the designer must have a constant access to a large amount of information. A conventional graphical representation of design data "a plan" contain a considerable amount of information which is available continuously, since in the design process the decisions are taken on the basis of relations between individual pieces of information.

2.4. Means of access to the Design Data Base.

A delimited set of information, which is operationally justified forms the workplace. Within this entity one can distinguish two subsets of data records: the former called drawing, and the latter called environment.

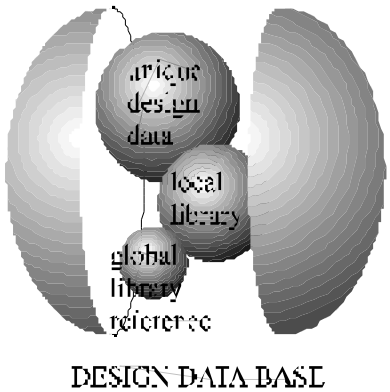


3. Scheme of access to DDB

The distinction between them lies in the difference in the rights of access to the respective groups. The records stocked in the drawing are entirely accessible for the user, and he/she has the right to modify them while the environment contains records with "the read" only attribute. The question arises how stable such sets should be. As I have mentioned before, they should contain a selection which is appropriate for a fixed goal. Theoretically, we can imagine a system which only instantly locks single records without creating fixed subsets. It seems however, that fixed sets (such as workplace) better represents the idea of individually defined scope of work.

2.5. Proposal for Design Data Base Structure

By now I have discussed the problem of individual scopes of work as if they were separated, but in the actual design process we have to deal with interlacing scopes. When two limits interlace they have common, that is the same, problems to solve. Since for the same problems there may exist different solutions, it is necessary to add a device to the system which will prevent from such situation. Different solution for the same or similar problem leads to the fall of consistence or even contradictions in the design, and therefore, they should be avoided. To understand this problem better, let's examine an example of a final documentation printed on paper. When one examines such set of drawings, one can find frequent repetitions of the same or almost the same information, like i.e. details of section. Such repetition is necessary in the construction process, as many different teams construct the building at the same time and physically at different places. But at the design stage any repetition is a trap for errors, let me explain how it works. Most often one forgets about the fact that during design process problems are not solved at once and forever, what is more probable, they are revised later many times. The trap of redundancy appears at the moment of revision. If the design data base contains more than one occurrence of a particular information, we have absolutely no guarantee that later correction is made at every place the information is repeated. In practice, this depends on only on the memory of the designer. A solution for the repetition is to store the information only once in DB and then refer to it as often as necessary. A selection of repetitive information which is typical of the design, creates the local library subset. The process of the library definition runs parallel to the whole design development. It is then important to try to figure out which elements of the design are suspected to be repetitive and which are not. The whole process must run basing on such reflection. And finally the third element of the data base which might be optional: a list of objects from global system library. This list is necessary only in case



4. Design Data Base structure

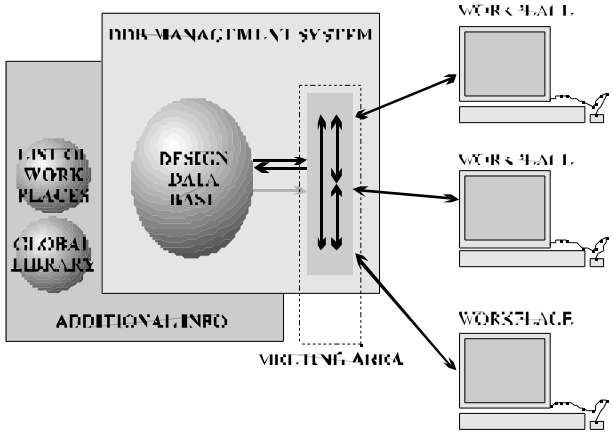
when the data base is to be transferred from one system to another. At the moment of transfer the listed elements are also transferred if they are not available in the other system.

2.6. Work scheme based on DB Management System

Let's examine the scheme shown on fig. 5. The nucleus of the system is a unified Design Data Base. The access to the data is driven by the management system which also plays the role of mediation medium between the individual designers. In this way the flow of information is under control of the system and any modification to the data base can be traced, checked and if problems occur, pointed out. This is the meeting area for constant data exchange. The notion of set of common rules can be continuously updated and in this way adjusted to the changing conditions. Additionally, the system stores also scope of work partition reflected in the list of work places, and serves "ready made" objects from global system library.

3. Examples of cad systems

The postulates formulated here have their roots in my experience with the actually used cad system I have had under control as CAD system manager. So let me present a few systems and the manner they are adapted for the concurrent type of work.

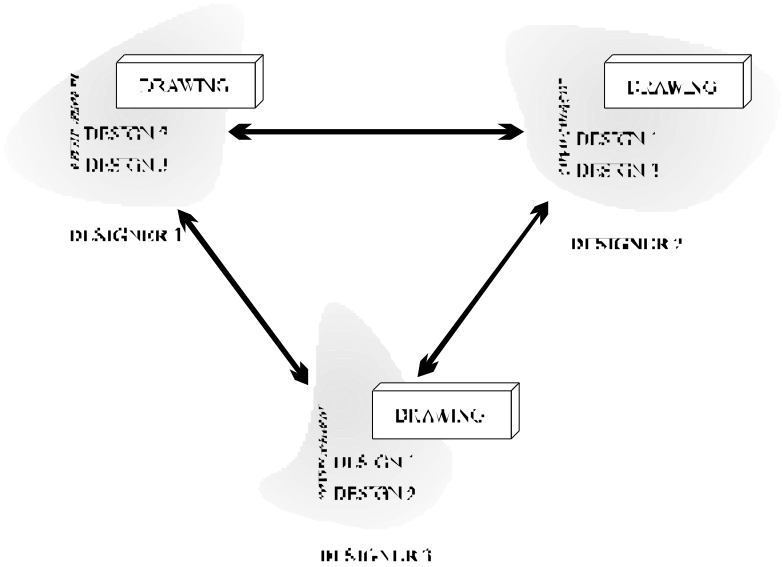


5. Organisational scheme of DDBMS structure

None of the systems I have examined really supports the structure presented in the theoretical model, however, many of them offer different commodities which partially fulfil the stated priorities.

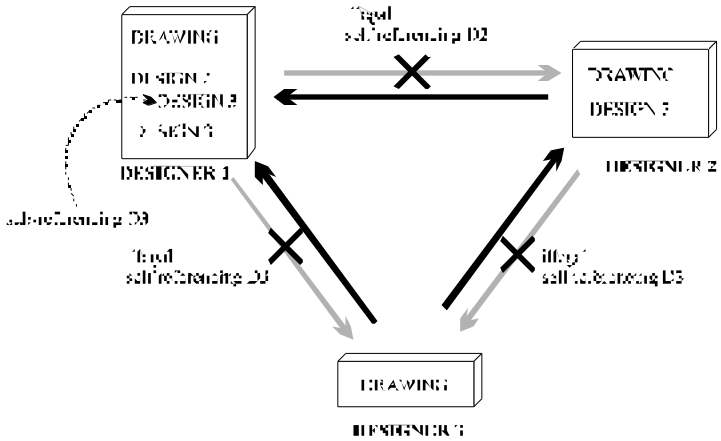
3.1. Data base structure

Starting from the central point of the theoretical model, the unified data base, we can notice that none of the systems can offer such structure of data storage. The design data is actually stored in separate smaller and independent data bases. So the actual organisational scheme resembles to the one illustrated on fig.2. In that way no means of automatic consistence control are provided. Instead of united data base most systems offer means of joining separate data bases. As we focus on concurrent work here appears the problem of simultaneous work on the basis of equal right. Let's examine the scheme below. Our searched structure permits mutual access to the data.



6. Searched data structure

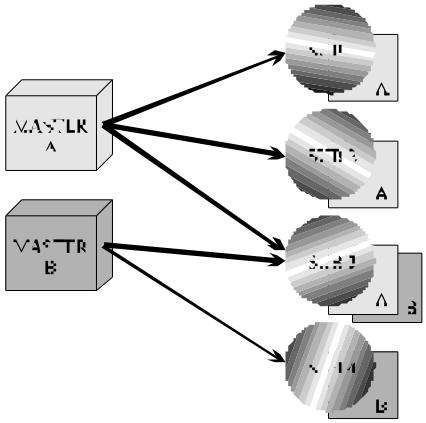
But actual structure of the data is different. The information which serves only as the environmental data is put into the active drawing, and in this way becomes an element of the drawing data base. At this moment the problem of self referring appears. It is presented on the scheme below.



7. Actual data structure in available CAD software

As I have stated before, the concurrent work requires means of exchange of information in the negotiable manner. What I mean is to get insight into the work of other members of the group. As one can notice on the above scheme such situation is impossible because the side information becomes an integral part of the active data base and the problem of self referring appears. In this situation a parallel work is possible only if mastering part of the design can be delimited and on such basis a subordinate design might be developed. The fig. 8 illustrates such organisational pattern. The scheme can be translated into design practice in the following way: the architectural part of the design plays the role of a master and the branch designs like electrical, plumbing or H.V.A.C. take the subordinate positions. Actually, this is

an example of concurrent work but the separate branches do not have the opportunity to check their mutual relation.



8. Scheme of possible junction of design data bases in CAD systems

In specific CAD system the above discussed scheme is embodied in different ways and offers quite different commodities.

3.1.1. ARC+

In the specialised software ARC+ 11.03 by ACA Ltd, meant for architects, the junction of the design data bases can be attained thanks to the concept of placed objects. As a means of joining two separate data bases it does not offer much. The attached data base can be scaled and it is updated only once during the work session at the moment of the opening of the main data base. The system does not allow any control of the layer structure of joined DB so we cannot control and filter its appearance on the screen. The placed object can also be merged with the main data base.

3.1.2. Autocad

As one examines a different software like Autocad 12 by Autodesk Ltd, one can find different means of joining separate data bases thanks to the concept of external references: xrefs. This concept was specially developed in order to permit certain way of parallel work. It offers the opportunity to control the visible structure of joined DB through a well-developed layer management. Thanks to this feature one can select only this part of the design which is actually needed and disregard the rest of the data. Xrefs can be scaled and they can be updated during the work session.

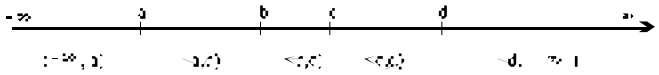
3.1.3. Archicad

The Archicad by Graphisoft does not offer any means of joining separated data bases. The only way to join different parts of the design is merging. Thus practically, the model of concurrent co-operative work cannot be implemented.

3.2. Partition of design data

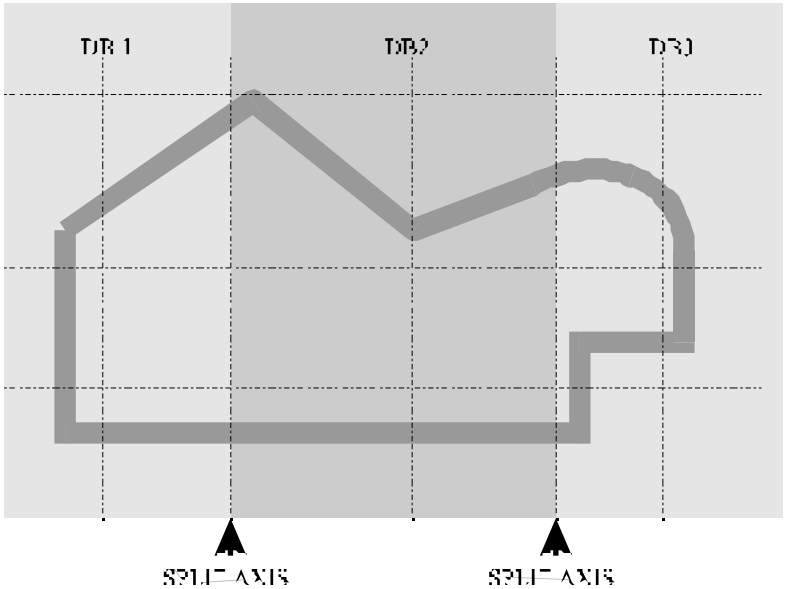
As it has been pointed out earlier, the actual cad systems requires the split of the data into independent files in order to permit simultaneous access to the design data. A crucial factor for successful restitution of entire data is the right and clearly defined method of partition.

The basic thing is to avoid redundancy of the design data. Let's try to make a comparison of the design data base to an axis of numbers. To make a split of numbers into continuous sets of non repetitive elements we can delimit compartments of open/close edges.



9. Non repetitive split within the set of real numbers

In a similar way we can imagine the split of a plan along structural axis.



10. Split implemented in the design data

Strictly done split allows automatic restitution of the entire data. Additionally, if there is no redundant information, reliable reports can also be extracted from the such data bases.

3.3. Libraries of repetitive elements

The repetitiveness of the design elements is the other concern of the coherency in the design. The same structure which is used to join the data bases can be used to insert the repetitive elements into the design. Then the whole set of inserted elements forms the local library.

3.3.1. ARC+

In this software placed objects posses very interesting feature, which can support the construction of the local library: the parametrisation. As I have stated in the previous paragraphs one of the clues of coherent data bases is the uniqueness of stored information.

The parametric objects allow to create repetitive entities with the necessary adaptability. This feature is very useful as the repetitive elements often slightly vary one from another according to the specific local conditions. In terms of ARC+, parametric object is an object with variable internal dimensions. When one places such object, a numerical value for each parameter name must be specified. The corresponding dimension of the object is stretched or compressed to the specified values. It is possible then to choose whether to display or to hide the dimension lines of the object.

3.3.2. Autocad

Xrefs implemented in Autocad does not offer such flexibility; they are, however, a very useful tool in keeping the design consistent.

In both cases the elements placed (attached) can be modified independently from the main data base. In this way all their instances in the design data base are automatically updated if any modification happens to them.

3.3.3. Archicad

In this software, it is possible to construct libraries of parametric objects thanks to the implemented GDL language. As this software is not oriented towards simultaneous group work they can be used only within the singular data base.

4. Educational implications

The above discussion have some implication for educational process. During the study process students are not used to collaborate on the design development while in the design practice such way of work dominates. Nowadays, when cad systems are more and more present in the design process it seems worth attracting students attention to the problems of concurrent collaborative work regardless the software they will use in their practice. The points concerning the widely available cad systems can help students to deal with the problem of automatic coherency in the design as well as they should draw attention to the potential traps and problems relating to the concurrent work.

5. References

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