INTEGRATED COMPUTER AIDED DESIGN. PRESENT AND FUTURE DATA STRUCTURES.

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1. INTRODUCTION.

Below are some viewpoints given on data structures which may mirror the building process and act as a platform for further discussions and development of integrated computer aided design systems.

The emphasis is upon the necessity to find a sufficiently valid general approach to system development in order to meet the galloping evolution within the field and the demand for development strategies.

I think it is vital to aim at the formulation of system modules that possess a high ability to adapt their behaviour to fundamental human values and a complex and unstandardized (not uniform) building process but at the same time put contraints on them so that we don´t end up with a confusion of computerized routines hard to access, control and understand. It is important that we formulate a basic skeleton outgoing from the properties we want to give integrated CAD systems and to those rules by which the growth of the systems are governed. I am in this connection referring to prospects of using the 5:th generation computer technology in the design and use of systems.

We can foretell a radical change in the use of computers. The end-user will be less concerned with programming in the old sense of the word and act more as a creator and manipulator of information. The CAD environment will to a higher degree than before possess human characteristics in that we will slowly build in human standards originating from the design language and our way to represent information today. The possibilities to reason with computerized systems is a new and very beneficial concept within the field.

It is meaningful now to introduce computer resources to a higher degree than before because of increased availability both in time and space (many terminals, wider ´windows´, colour, local and global networks, fast graphic output, storage on video disc, 32 bits micros). The tools to build systems on a higher level exist, e.g., program generators, relational database management systems, real time user programs and soon the 5:th generation systems. New standards or de facto standards are being forced into acceptance faster than before due to high pressure from the market (IGES, GKS, ´UNIX´,...).

2. THE BUILDING PROCESS.

The basic elements of the process are
1) labour
2) information (knowledge)
3) material
4) product

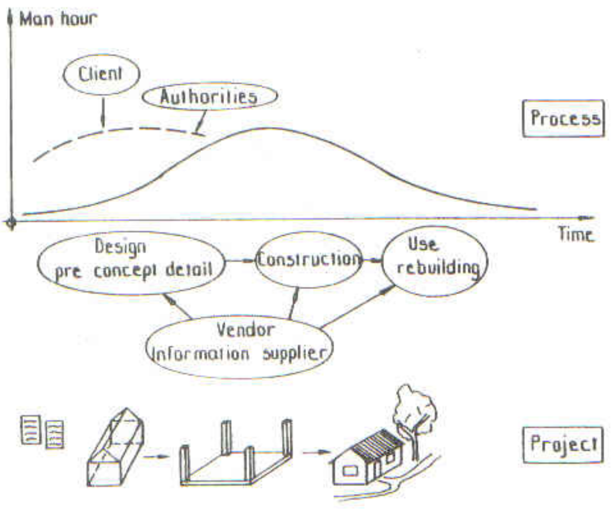

Figure 1 The building process and building project.

I think it may be wise to separate the project from the process before a more detailed structuring is outlined.

Building process: active elements are man and machine.

Building project: from model to product and its documentation.

Each contains flow, storage and manipulation of information (and material) and mechanisms to control these activities.

The main goals to be fulfilled when computer resources are introduced are

a) increased quality on work content and produced results
b) flexible and adaptive process environment and project descriptions, including interaction with manual routines.
c) increased productivity

3. DEFINITION OF LOGIC STRUCTURE.

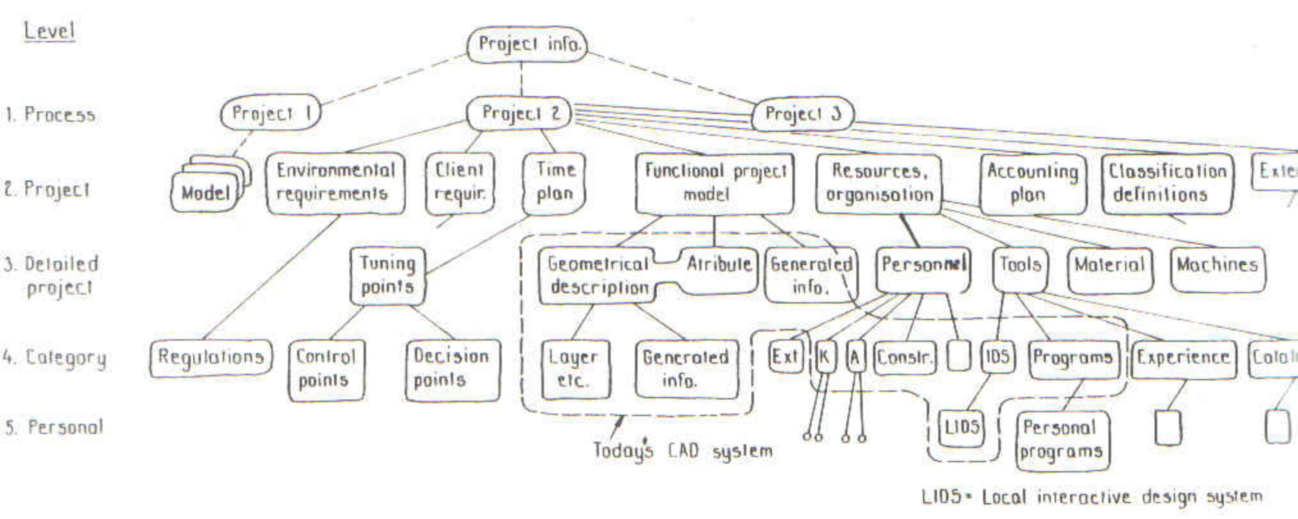

Figure 2 Process information and control structure, PICS.

The logic structure (scheme) in figure 2 is intended to be a platform for further discussions on integration, especially within the field of CAD. The logic structure will not be discussed in detail in this paper.

Today we possess computer tools which fit in the scheme but are very loosely coupled See, for example, the available CAD systems which mainly reside within the dashed line of figure 2. The structural engineers have long used tools for engineering analysis which until now have only sparsely been integrated. This is also to some extent true for the architect´s tools used, for example, to evaluate different design solutions in the pre- and conceptual stages of the design, though more frequently to produce working drawings and building descriptions.

Systems for word processing are widespread, often on small free standing systems as well as programs for graphic accounting and interaction (business graphics, spread sheet programs). Mail and message systems are now beginning to be introduced.

The strategy for integration should be based on small steps of well defined functions of new and existing software aimed at systems that are sensitive to requirements from process and project, though a mutual influence between computerized and manual systems is inevitable and desirable.

PICS can serve as a master module containing information, performing actions, connecting process activities and project information (both computerized and manual, external and internal). PICS can also contain and give status information as well as access rules to data banks and programs, handle messages, etc. Just as with other parts of the computerized system it should not be too sensitive to information ´holes´, i.e., default values or user intervention will fill out these holes temporarily.

Referring to figure 2 some comments are given:

Level 1 (Process level):
Contains pointers to related projects.

Level 2 (Project level):
Contains pointers to superior information on current project. The project model on this level is very much a functional description of the project.

Level 3 (Detailed project level):
Contains pointers to detailed requirements on the project (from clients, regulations, etc.) as well as detailed time plans and accounting plans (internal and external) and available resources (personnel, software tools etc.). The project model might on this level form a link between the more abstract higher level and the lower more detailed sub-models (see also figure 3). Project information could be made available to succeeding phases in the process as the construction phase, though in a suitable form (little constraints should be put on the input data to the construction team).

Level 4 (Category level):
On this level the project teams are connected in the early design stage supporting the very vital integration between categories. Access to regulations and catalogues and other externally supplied information can be accomplished on this level.

Level 5 (Personal level):
On this level local interactive design systems, LIDS, can be defined containing personal tools as experience data, checklists, own programs and temporary information storage.

Tomorrow´s systems will contain project information which should be highly accessible to many persons during all the design phase of the project. Figure 3 gives an idea of the content of the project model composed of descriptive text (free and/or standardized) and graphic information which will probably be more 3D than 2D in the early design stages (it is hard to store a ´complete´ 3D modell in a computer system except for small projects).

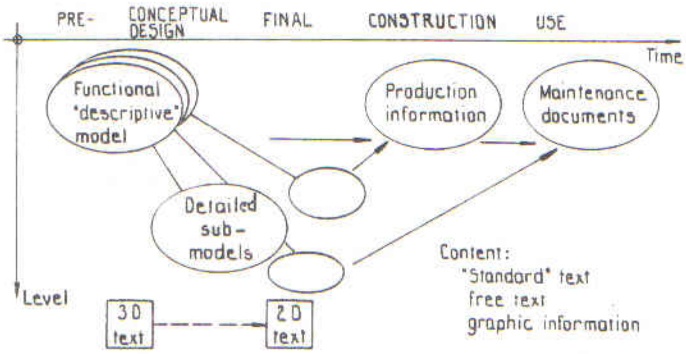

Figure 3 Project information

In big projects, relations between sub-models probably should be established meaning that information could then reside in different sub-models and hopefully in a non-redundant way (stored in one place), see also Richens /1983/.

It should be possible to integrate new tools (programs, sub-systems) into existing systems preferably with great system assistance during the implementation, test and documentation phases. Such tools might be personal or common programs for analysis, modules which could capture and store experience on different PICS levels, etc.

Examples of the first generation of integrated computer aided design systems are CAEDS, Computer Aided Engineering and Architectural Design System, developed at the Construction Engineering Research Laboratory, USA, see Spoonamore /1983/, Borkin /1982/ and BDS, Building Design System, developed at the Applied Research of Cambridge, UK, see Hoskins /1979/.

4. LOGICAL VERSUS PHYSICAL SYSTEM STRUCTURE.

There is a clear trend to a more widespread use of powerful micro computers with hard discs and big address space. These machines can often be connected in local area networks if they originate from the same vendor and they can often communicate (primitively) with central mini computers or main frames. The local interactive design systems of level 4 in PICS can well be located in such systems with access to common modules of higher levels where the requirements with respect to transfer rate are not that crucial.

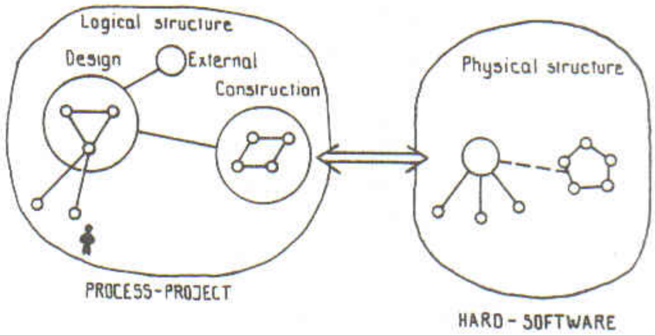

Figure 4 The logical and physical structures do not have to map one to one.

The connection of (communication between) project sub-models may cause problems especially if information which possesses some kind of intelligence is to be transferred, i.e. if the information shall have a meaning to the receiving system and if inquiries are to be made from one system to another. Work within this field has been done (within the CAEDS project) and has begun elsewhere (in Sweden).

The ability to create real time program user environments may be a way to design flexible and adaptive systems in so far that independent modules can be defined, tested and introduced to the system with little interference to the rest of the system and because such programs, in interaction with other modules, can perform specified tasks (like in an operating system, using ADA?).

5. MEET THE NEXT GENERATION.

Behind the corner (5 years ahead?) a more widespread use of the 5:th generation computer technology can be expected. In Japan a 5:th generation computer already has been launched. To meet this development it is very important to tackle the problem of structuring knowledge and making classifications which are universal enough to be used in integrated systems.

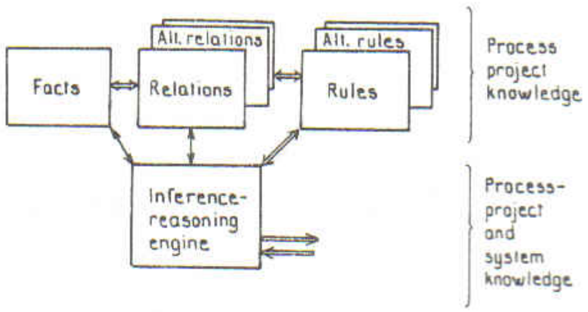

Figure 5 Facts, relations and rules are parts of our ˝standardized˝ reality.

One way to start is to formulate a very universal base classification which can be called facts (performance characteristics, loads, structural characteristics etc.) and then apply different sets of relations to them to fit different situations (design, evaluation against regulations, design of personal experience bases etc.). Finally on a higher level rules are defined which may be in the form of decision tables.

The reasoning mechanism (the inference engine, with expert system vocabulary) must leave all important decisions out to the end-user and also make stored information (knowledge) accessible enough for the user and movable to new systems. This is especially true when the end-user is synonymous with the expert himself. Existing building regulations can be regarded as manual expert systems and therefore give valuable information when defining a basic skeleton of facts, relations and rules. A building code expressed as an expert system will be usable even if it might be regarded as a black box to the end-user (is a requirement fullfilled?).

Work within the field is, among other places, being performed in the USA, Australia, UK and Japan, see for example Bijl et.al. /1983/, Feigenbaum et.al. /1983/, Gero /1983/, Harris et.al. /1981/, Lansdown /1982/, Lopez et.al. /1984/ and Stahl et.al. /1983/.

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