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PROBLÉMY VÝMENY INFORMÁCIÍ MEDZI MODULMI NA 3D MODELOVANIE A NAVRHOVANIE TECHNOLOGICKÝCH POSTUPOV

INFORMATION EXCHANGE PROBLEMS BETWEEN 3D MODELLING AND PROCESS PLANNING MODULES

Cielom tohto projektu je vyvinúť nástroj komunikácie medzi 3D CAD a navrhovaním technologických postupov. Sú prezentované doterajšie výsledky: (i) Prenos CAD dátového modelu a iných informácií o výrobku z 3D CAD systému (Solid Edge) do databázového modulu, (ii) modul na klasifikovanie prvkov a súčiastky. Tento prístup je založený na STEP technológii s cieľom definovania počítačom podporovaných nástrojov na štruktúrovanie dát a menežovanie vedomostí o výrobku implementovaných v relačných databázach. Problémy opisu prvkov a súčiastky predstavujú kritickú časť. Prvkové modelovanie pre 3D návrhové činnosti patrí k najefektívnejším prístupom. Pre rozličné oblasti použitia sú predstavené rôzne prvky (konštrukčné, technologické, nástrojové prvky a pod.). V tejto oblasti nebola dosiahnutá dohoda a používané termíny často nie sú jasné pre užívateľov. V článku je podaný preto krátky úvod riešenia horeuvedených problémov.

The objective of this project is to develop a tool for communication between 3D CAD and process planning. Our accomplishments so far have been: (i) Transfer of the CAD data model and other product information from the 3D CAD system (Solid Edge) to a database module, (ii) the part/detail and feature classification module. The approach is based on STEP technology to define computer-aided tools for data structuring and management of product knowledge implemented on the relational database. Problems of part and form feature description play a crucial role in this framework. In 3D modelling Form Feature (FF) based design activities are the most effective approach. A number of FF definitions have been introduced for different implementations (design features, manufacturing features, tool features etc). However, the consensus in the field has not been reached and often the terms used are not clear for the users. In the present paper a short introduction is given to solve the afore described problems.

1. Introduction

Manufacturing of tomorrow will be digital information driven. Effective utilisation of manufacturing information and knowledge will be a key issue for manufacturers of all kinds of products. There is a strong need in the industry to have a standard for the digital representation of manufacturing systems and the integrated design and manufacturing environment as well. Such a standard will enable sharing data from different vendors of components to be integrated into a consistent model of the product or the manufacturing system being designed (Fig.1).

2. Background

Most industrial companies today use a large number of computer applications in their product realisation processes. A large amount of data/information about the product is created and used individually by different engineering applications during the product lifecycle (Fig. 2). Much of this information is common for all applications and could be shared but it is not shareable

today. As a consequence, the creation and support of this data/information is currently time and cost consuming.

Process planning and production planning for manufacturing processes are still most times two distinct sequential off-line activities. Process plans are ordered sequences of tasks able to transform raw material to a final part or product. Tasks are chosen taking into account available or potential production means. Production planners receive process plans as their input and a task is to schedule the tasks on the machines while respecting the precedence relations given in the process plans. However, decisions made at the process planning stage, e.g., selection of machines, selection of task sequence, constrain the available choices for optimisation on the subsequent production-planning phase. On the other hand, process planning and scheduling may have contra dictionary objectives, such as required technology versus resource usage. As such, process planning forms the link between design and manufacturing. The tools and processes available in a given shop greatly influence the way in which designers and manufacturers view a part and the way in which they decompose it into machinable volumes, or features. By

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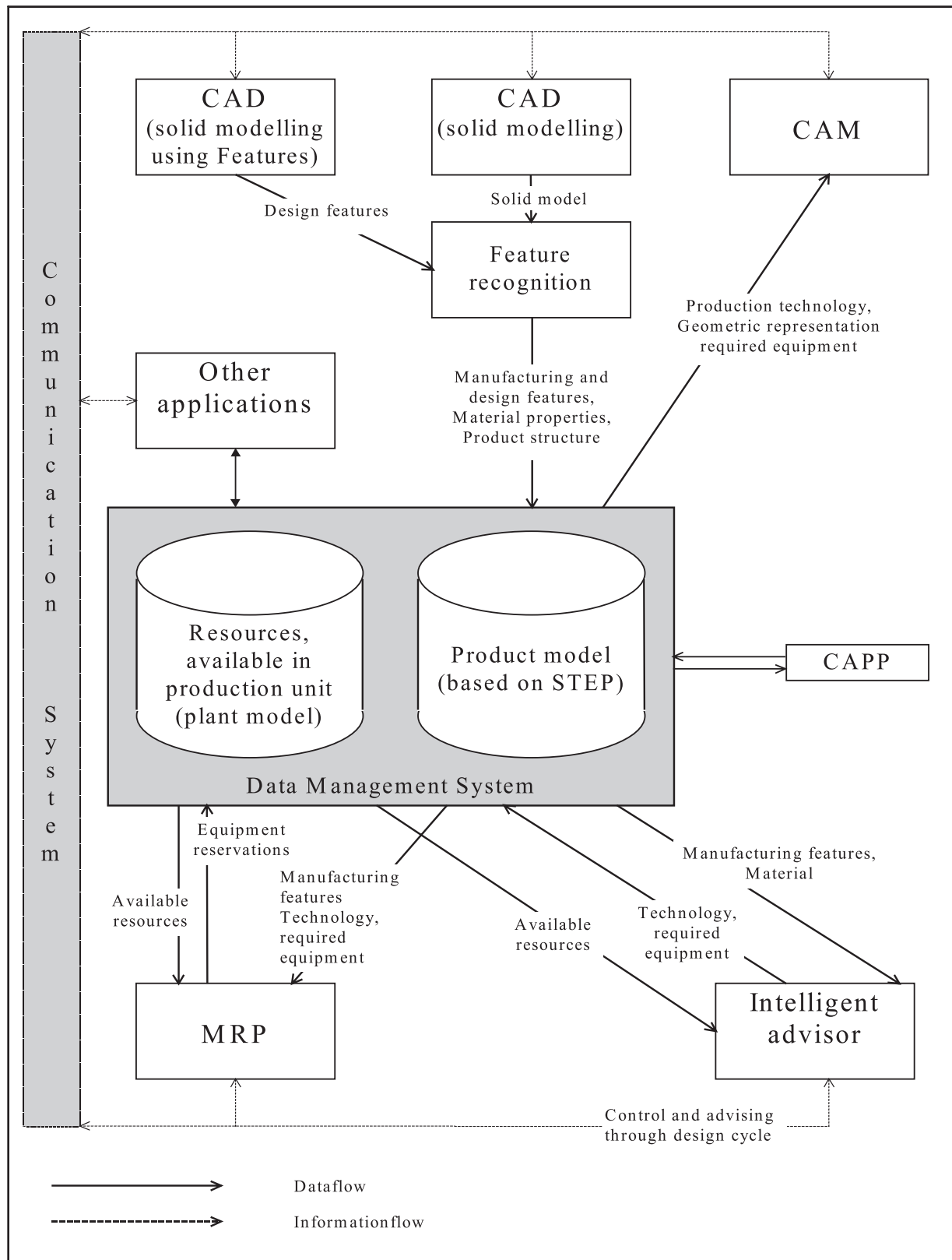


Fig. 1. Integrated Design and Manufacturing Environment

introducing features as primitive for representing product life-cycle aspects, the efficiency of modelling product database can be improved considerably.

3. Product information modelling

Most up-to-date CAD tools are developed for representing the geometry of components. However, information about geometrical component (feature) e.g. holes, pockets etc. and their relationships, tolerances, surface finish, etc. is missing in the geometric data models. This information is essential for manufacturing planning process, and therefore, the representation of features at the design stage is significant for the integration of CAX system. A Feature information in CAM includes most of the design data stored in the CAD system. Therefore most of the feature data in design system can be directly transferred to the manufacturing data model. The other problem is feature classification. There is no consensus by now in the field, so different variations of feature definition exist.

One of the most significant approach today in product modelling is the development of ISO 10303 [ISO 10303-1] standard called STEP (Standard for Exchange of product model data) which defines models, database access and neutral data file format for representation and exchange of product data (Julian Fowler). One

task of the entire project is to ascertain the efficiency of STEP standard (AP203, AP244) for describing features. For this task, now well known data modelling language EXPRESS has been used. In the later phase for data exchange between applications two methods could be used, via neutral file (*.stp) or via the STEP database interface SDAI (Simple Database Access Interface) using commercial tool from Steptools Products - ST-ORACLE (Goh. 1994).

4. Implementation

Manufacturing planning systems need to extract feature-based component information from CAD systems both accurately and efficiently. Currently, there are two main approaches to obtain feature information automatically from CAD systems, i.e. feature recognition and design by features (Mäntylä, 1994), (Salomons, 1993), (Gao, 1991), (Joshi, 1988). With the first approach, features are recognised from a Boundary Representation (Brep) or a Set-Theoretic model of a component via a processor or feature recogniser. Technological information about the features (the manufacturing implications for example) has to be added after the recognition process. The problem with this approach is that the recogniser can become very complicated as more complex features are to be identified, and there may be some features which cannot be recognised. With the second approach, features

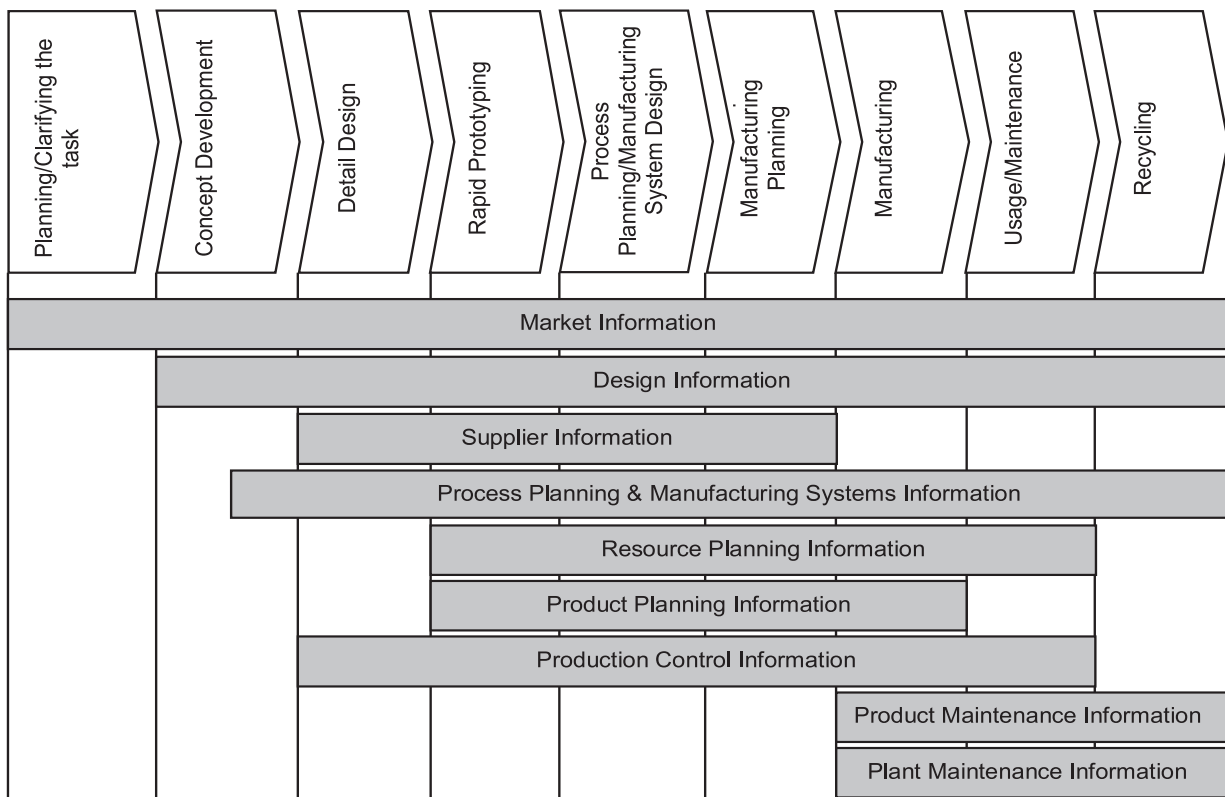


Fig. 2 Information needed during the product life cycle

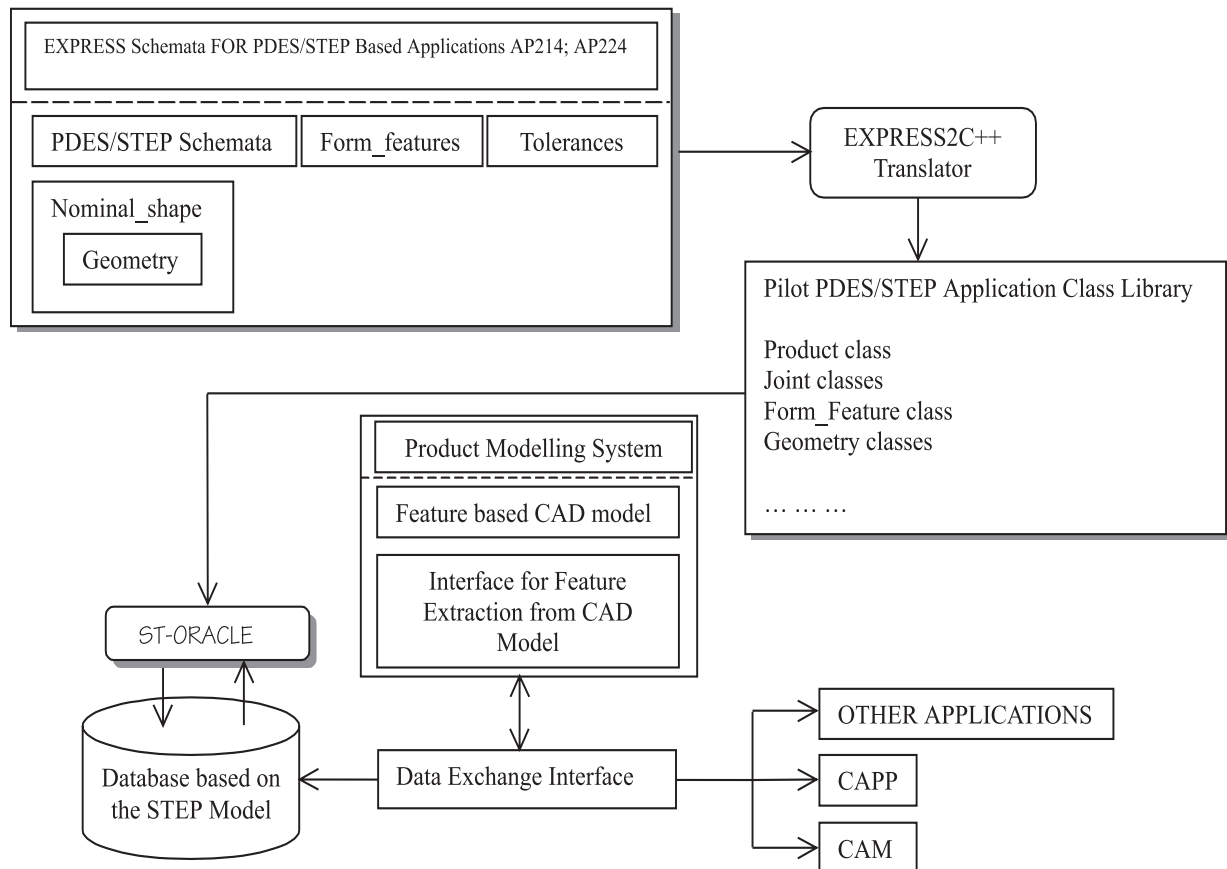


Fig. 3. Communications bus between 3D modelling and process planning

can be recognised directly from the model in a runtime mode. In our work we are using the second approach. After the recognition process the extracted data will be stored in to the database using a data exchange interface. Our prototype runs under MS Windows and uses a standard computer.

To manage the data we use relational database ORACLE V7 (Fig. 3). As mentioned before for converting EXPRESS entities in to relational database we use commercial tool - ST-ORACLE.

4 How to consider features on the planning stage

Briefly about our consideration related to form features. FFs are mainly considered as pure geometrical forms.

Actually, more information is needed for engineering activities. So, the FF-specific attributes are needed. According to J. Shah four requirements the feature should at least fulfil, are:

- It has to be a physical constituent of a part;
- It ought to be mappable to a generic shape;
- It should have engineering significance;
- It must have predictable properties.

Hence FF is defined as:

$$FF = FF(X_f(I), \Delta_r(I), Q(I)), \quad (1)$$

where $X_f(I)$ is dimensions of the FF, $\Delta_r(I)$ is tolerances of FF, and $Q(I)$ is quality data of FF.

The set of FFs on the part has to be defined by their mutual location, hence the FFs interface has to be defined.

$$FF - interface = FF(x(i), \Delta(i), R(i)) \quad (2),$$

where $x(i)$ - dimensions, $\Delta(i)$ - tolerances, $R(i)$ - rules to complete the part.

FF can be simple or complex. To complete the complex FF the interface is needed as well as to define location of it on the part. Beside this, *temporary FFs* are used, for instance, centre holes for machining if the designer has not foreseen these and they would be excluded from the ready part.

How to gain the part condition defined by the designer depends on the skills of the process planner and manufacturer. If FF (in

the sense of design feature) for particular part is defined quite clearly, then the manufacturing feature can have multiple contents. Different experience of a process planner, different tools and machine tools to be used etc.

The difference between design features and process planning features has been indicated and it can be considered as multiple view problems (principle of the FF forming). But sometimes the difference is caused by different consideration of the feature meaning (manufacturing feature - geometrical form with production information). As an example, a tool-feature, set-up-feature and a machine-feature are introduced by (Deneux 95). Such approach is not convenient from the point of view of heuristic planning.

No manufacturing specific information is explicitly present in the form feature description. The manufacturing information will be retrieved from the geometrical representation of component alone taking into account constraints in the form of FF attributes. So, actually we can speak about the *design features and activity oriented computational features* during the product life cycle. The main objective of the manufacturing process is to gain the product in its different stages with predicted quality in a very wide sense. There is a lot of ways for this depending on the process planner's experience, knowledge, manufacturing environment etc. Predefined terms with different meaning are the main source of problems by data exchange between different modules. As consequence, the intermediate stages of parts and FFs as derivations from design FF have been used in our activities.

So, the initial blank's form and dimensions will be defined by "backward chaining" - from the finishing tool with needed set-off

to roughing tool. As rule, the result depends on lot size and possible tool set for the present FF, as well as on the planner's experience.

During the activities toward the manufacturing, FF has to be considered as a physical constituent of a part. To machine the hole in a shaft one possible set of tools is possible, but the same hole in the body can be machined by another set of tools. This underlines the fact that pure tool-feature is not quite clear from the point of view of manufacturing planning activities.

Instead of using the term "quality feature" the specific bill of rules for the quality definition of a particular part is needed. Information for the quality control activities will be extracted from the design FF's semantics in the form and content as needed.

From our point of view such an approach enables to eliminate diversity of terms and create an opportunity to derive the needed information for particular application

5. Conclusion

By letting the computer applications have a common description of the manufacturing resources, in an information model described in computer interpretable format, we can minimise the time and money spent on data exchange problems. Such a problem solving support strongly the virtual manufacturing as well.

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6. References

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