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INFORMATION SUPPORT IN AN INTEGRATED PRODUCT DEVELOPMENT SYSTEM

Abstract. Computer-aided design systems require a comprehensive information interaction capability in order to support team-based design. This paper focuses on research concerned with providing this level of support through the use of a number of related information models. The provision of a common sharable information environment plays a critical role in an integrated product development process. Whilst the need for information models is well known, the problems of how they should be structured and the relationships and interactions between them have yet to be understood. In this paper we identify three information models as important: a product model, a manufacturing model and a product range model. The structure of these models is discussed and an approach is offered to some of the information interaction problems.

INTRODUCTION

Whilst the understanding of the organisational needs of the concurrent engineering philosophy have advanced significantly over recent years [1], the computational tools to support team based design have yet to show the same level of development. Typically Computer-aided design systems are geometric modelling systems and do not provide the comprehensive information interaction capability which team-based design requires [2]. This paper focuses on research concerned with overcoming this problem through the use of a number of related information models to support design decision making.

The provision of a common sharable information environment plays a critical role in an integrated product development process[3]. Whilst the research needed to achieve such an environment is substantial, the successful achievement of such an environment offers significant potential benefits to system users.

Product models have been recognised for many years now to be a means to the provision of a common source of product information to support integration and data sharing [4]. However in this paper we recognise three information models as important: a product model, a manufacturing model and a product range model. Product models provide a source and repository for information concerning a

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product under development. A Manufacturing model by comparison represents the capability of a manufacturing facility and can therefore provide manufacturing related input to design decision making [5]. A product range model provides a historical perspective on the design of particular product types [6]. The problems of how information models should be structured and the relationships and interactions between them have yet to be clearly understood [7]. This paper discusses the issues involved in information model support for product development and offers an approach to overcoming some of the information interaction problems.

INFORMATION MODEL ISSUES IN PRODUCT DEVELOPMENT

A wide range of information is needed to support product development decision making. Given the global nature of many modern companies this information must be communicated at a global level as individuals in a design team are likely to be based in different locations throughout the world. An illustration showing an example of some information types needed to support product development is provided in figure 1.

Figure 1: Example information inputs to product development

There is a distinct difference between information that is provided as text for user interpretation and information that is sufficiently structured that it can be interpreted by software applications. It is assumed that all information models provide sufficient structure to provide software support. The issues to be resolved in information model support for product development can be raised through two simple questions:

1. What information contexts are needed to support product design and manufacture in a global design and manufacture environment?
2. How can information be shared across these multiple contexts?

Finding the answers to these questions is not easy as is evident from the wide range of international research and the efforts of the ISO STEP groups over recent years [3,4,5,7,8]. Figure 2 provides a general view of an information supported integrated product development system. This highlights the separation of the applications which support design from the information which they use. This is an essential aspect of integrated information systems support and offers the potential advantages of complete data integrity, rapid flexibility, maintainability, vendor independence and life cycle support.

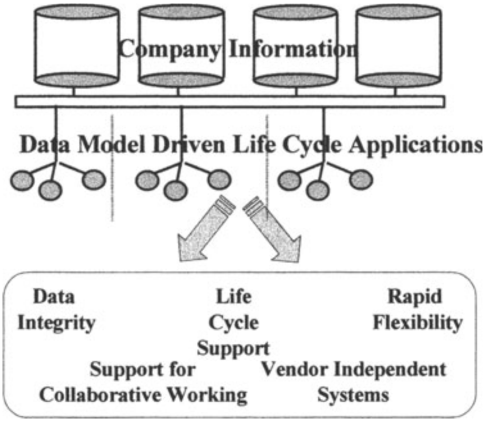

Figure 2: Information Supported Integrated Product Development

The pursuit of an information supported integrated product development system raises a number of issues as follows:

1. What functions in the product development process should be supported?
2. What types of information model are needed to support each function?
3. What information structures are needed to support the input and output of each function?
4. What information needs to be shared between functions and how can this be achieved?
5. How can flexible information systems be achieved which can be readily maintained and updated?
6. Do information models just capture information or are some of them knowledge models?
7. What characterises a useful set of information systems design tools?

THE FUNCTIONAL REQUIREMENTS OF DATA MODEL DRIVEN PRODUCT DEVELOPMENT SYSTEMS

The functions to be supported will depend on the particular development process to be supported. In order to explore the issues in information model supported integrated product development this work has focused on the interaction between design for manufacture and manufacturing planning in a global environment. An example of interacting functions involved in the design of an injection moulded product is illustrated in figure 3. In this example the plastic product and the mould provide the key product information contexts for the design and manufacturing functions. However there are many sub-contexts to be supported each of which has its own information requirements.

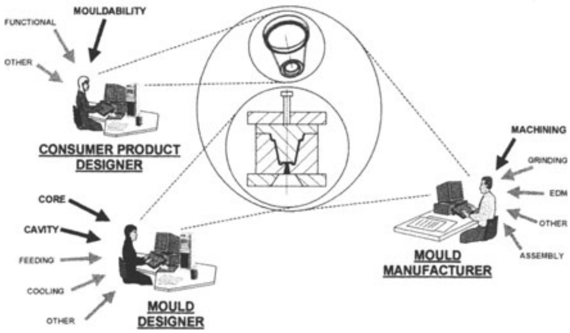

Figure 3: An example of multiple functions in product development

The basic concept of information model supported product development is that any software function that is involved in supporting product development will draw on the information models for information inputs and will supply its outputs into the information models. Figure 4 shows three example applications to support the development of an injection moulded product. Each of these applications draws product information from a product model and manufacturing information from a manufacturing model.

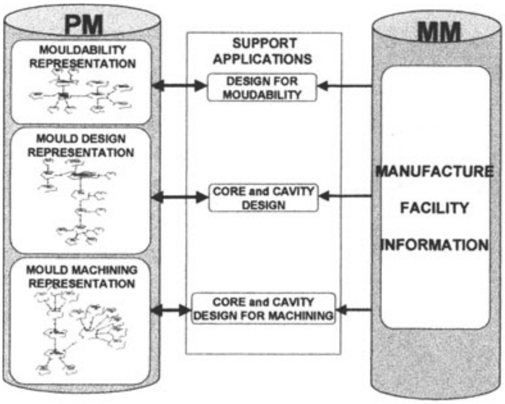

Figure 4: Different information contexts to support specific applications.

The product information for each application is specific to that context. Hence the design for mouldability application has a mouldability context, core and cavity design have a mould design context and core and cavity machining have a mould machining context. Necessary manufacturing information concerning injection moulding machines and machining processes are drawn from the manufacturing model. The significance of these information structures is that interactions between applications are handled via the information models. The only constraint on the action of an application is the availability of information in the information model. Interactions between applications must therefore be dealt with via interactions between the information in the models.

A further necessary information model is one which can provide information concerned with previous designs and support design re-use. This can be achieved in variant and adaptive design through the use of a product range model which captures sets of product functions and maps these to a sets of possible solutions. Specific solutions can then be identified for a particular design situation, dependent on the constraints and pre-conditions which apply in that case. A product range model, while having some similarity with a product model in that it is concerned with a product type, is substantially different in that it is concerned with capturing information concerning previous designs. The aim of the product range model is that the information which it contains should be re-used to support new product development.

THE STRUCTURE OF THE INFORMATION MODELS

The three models explored in this research are product models, manufacturing models and product range models. While further information models are likely to be needed to support the full product life cycle, these three are believed to be of particular importance.

As explained in the previous section, a product model must be able to support multiple information contexts if it is to be of real value in an integrated product development system. Such a model is considered to be at the heart of any such system as it must maintain all the key information related to the product which is under development. Figure 5 shows a UML class diagram of the general product data structure that has been defined into which multiple information contexts can be constructed. This is achieved through the *views* class, which can support a range of design views of a product, or manufacturing views of a product, or other views as necessary.

A Manufacturing Model is somewhat different in that it is concerned with manufacturing facilities rather than products. Its aim is to capture a representation of the manufacturing capability of a global facility. A general representation to capture this in terms of resources, processes and strategies has already been defined and reported [9]. However the relationships between resources, processes and strategies have not, until now, been clearly specified. Figure 6 provides an illustration of a manufacturing data model showing the dependencies between resources processes and strategies.

The product range model, at a simple level, captures links between the functional needs of a product type and possible design solutions. However, to be of value, the product range model must capture the interactions which occur between possible design solutions as well as being aware of the constraints which any existing design decisions may place on remaining options. A class structure for a product range model has also been defined in a similar way to product and manufacturing data models.

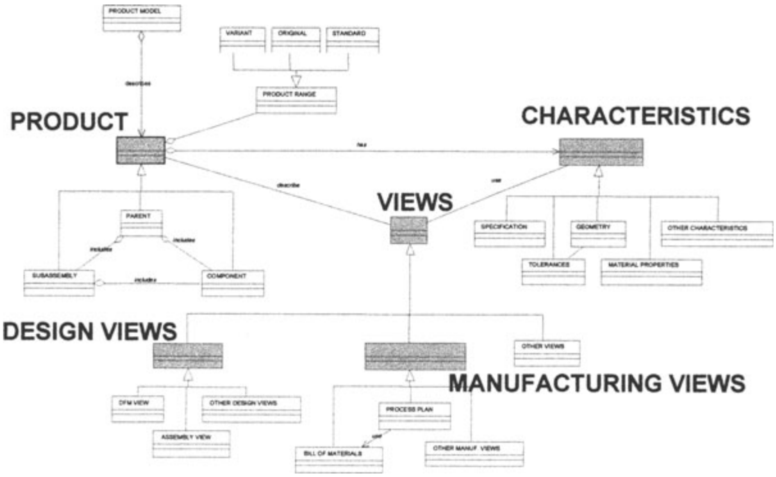

Figure 5: A product data structure to support multiple contexts.

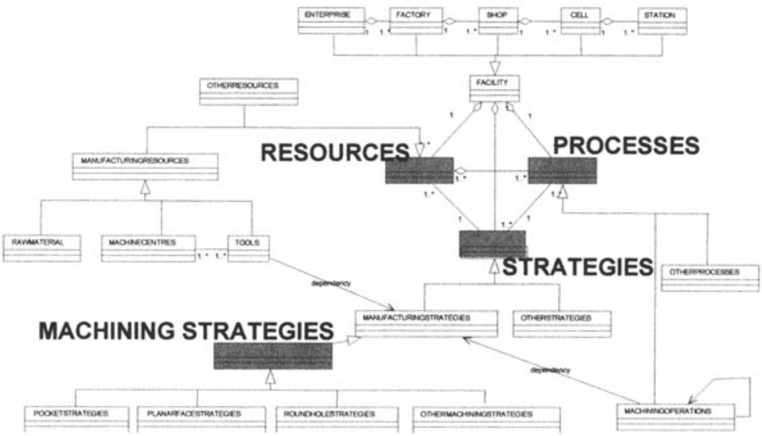

Figure 6: A Manufacturing Data Model showing dependencies between resources, processes and strategies.

INTERACTIONS BETWEEN INFORMATION MODELS

Although a manufacturing model is very different from a product model, there is a need for links between these models to be maintained to support interactions between product information and manufacturing capability information. This can be achieved through the use of common contexts. For example machining features in many research papers are considered to be part of a product model which provides input to a process planning application. In this research the alternative manufacturing routes for a particular feature are held in the *strategies* class of a manufacturing model. The product model captures a sufficient understanding of a machining feature, within the *dfm view* class to enable access to the information in the manufacturing model.

In order that chosen resources and processes from a manufacturing model can then be captured in a product model, parts of the same information structures can be used in both models. In this way design for manufacture and process planning applications can interrogate the information models to gain information and input results of decisions into the product model.

In a similar way a product range model can capture historical evidence of the alternative ways in which the functionality of a particular type of product can be achieved. Again this must be captured in such a way that a link between product model contexts and product range model information can be maintained. For example the data structures for particular design solutions in the product range model should match the data structures in the product model which must capture the design results.

INTERACTIONS WITHIN INFORMATION MODELS

The three information models of product model, manufacturing model and product range model all have information interactions which take place within the respective model. These interactions must be supported and maintained if a successful information support system is to be produced.

Given the central role which product models have in an integrated product development system, it is clear that maintaining information interactions within a product model are also central to the successful implementation of a product development system which can support multiple design contexts. If each application requires its own product data structure to maintain the relevant context as was illustrated in figure 4, then there is a need to develop interaction routines that maintain the relationships between the information within these contexts. This is highly significant for future integrated product development systems, as this need to understand and define relationships between views is critical to the future success of such systems.

CONCLUSIONS

This paper illustrates the potential for information model supported design and manufacture to offer a new approach to team based design support. Routes to solving some of the problems of information contexts and information sharing are highlighted. The need for a number of information models which go beyond the general approach of product modelling has been shown as has the need for the relationship between these models to be clearly defined within their information structures.It has been argued that mechanisms for the support of multiple contexts must be clearly specified before information supported integrated product development systems can be of real value to design teams.

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