Proceedings of the 7th WSEAS International Conference on Automation & Information, Cavtat, Croatia, June 13-15, 2006 (pp126-131)

Evaluation of Engineering Object Changes

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Abstract *-. Engineering modeling systems have moved into every day practice of engineers. Chains of model objects and their relationships are constructed by engineers using high level integrated modeling of wide range of products. However, integration of widespread information in application oriented subsets is a problem to be solved. Fortunately, built-in development tools and application oriented definition of engineering objects offers good opportunity for product based integration in these systems. The authors propose intelligent model object as intelligent organizer of information, knowledge, and procedures mainly for decision assistance.*
This paper discusses essential issues at evaluation of object changes in highly integrated model objects. Information content of the model and information subsets to be handled are introduced. Following this, effect analysis for changes of model objects and different states of adaptive actions are discussed. Next, associative connection definition driven organized communication of changes and combined intent based knowledge are explained as key issues in the proposed modeling. Finally, implementation for shape centered engineering objects in professional product lifecycle management systems is concluded.

Keywords: Shape centered modeling, integrated model objects, behaviors of modeled objects, intelligent decision assistance.

1 Introduction

Scene of engineering modeling has been moved from drawing tables through part centered computer aided drawing and modeling to product lifecycle management (PLM). PLM is a very highly integration of product modeling, product data management (PDM), communication of engineers, and engineering process specific multi site management. Integration of product modeling processes and product data representations is important in order to enhanced change management. Intricate relationships of modeled objects makes evaluation of consequences of change of an object at other objects very difficult. Continuous modification of huge interrelated data sets considering high number of affecting factors. Decisions of engineers during these modifications are motivated by their own intent and intent of other engineers. The authors concluded that a modeling that enhances changes by handling of relationships of modeled objects. Solution for this task is impossible without including human intent driven corporate knowledge. In recent modeling, elementary knowledge in the form of rules and checks, processing of parameter sets of instead of single parameters, and other means to receive results of intelligent computing are available. Consequently, recent advanced modeling systems are ready to accept procedures to solve the above problem with modeling.

The authors did a research in change management of product modeling. They considered modeling of products consisting of shape-centered parts and subassemblies. Generally speaking, the proposed methods are restricted to engineering objects where any other information can be attached to shape information. The objective of this research program is to develop highly integrated, intelligent, and high-performance model objects that include description of objects and their behaviors, human intent filtered knowledge, and procedures for model creating, simulation and communication procedures. The proposed model objects are intended as intelligent organizers of information, knowledge, and procedures, providing powerful assistance for decisions of engineers. Their implementations as auxiliary modules in open architecture engineering systems contribute to introduction of practice oriented application of intelligent computing in engineering. Results complete the presently typical simple data, rule and formula based relating of modeled objects by an intelligent solution.

Research in change management as reported in this paper relies on several earlier works of the authors. Topics of these related works are modeling of human intent in engineering [1], general characteristics of intelligent model objects for description of engineering objects [2], and extending the feature principle to the modeling of object behaviors and adaptive actions [3]. Adaptive actions are generated for proposed or enforced modification of interrelated engineering objects. They are defined as entities that carry information about attempts to controlled changes as a result of decisions during modeling. Two earlier works are cited by references [5] and [6] from the application of intelligent agents for interactive simulation and feature based parametric CAD/CAM.

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2 Information Content of Model

The authors introduced a concept of integrated model object in [2]. Integrated model object comprises computer descriptions of modeled objects as they are purposefully organized in a group. Information subsets in an integrated model object are concentrated around composition of elementary descriptions, behaviors, actions, communications, procedures, knowledge, and passport (Fig. 1).

Communications connect data, knowledge, procedures, actions, history, and on-going events to each modeled object. Humans with restricted responsibilities and authorities control the model object. Outside world is connected with integrated model object by interoperability functionality.

Information flow in change management is controlled by extended and advanced communications amongst decision makers. Communicated change information is analyzed by engineers holding the responsibility on engineering objects to be changed. Human intent originated or accepted knowledge is applied. In product model, constraining represent decided object parameters.

3 Effect Analysis of Object Changes

Present style of engineering is characterized by continuous development of products, manufacturing processes, as well as sales and other enterprise management related activities. Result of an engineering process at a moment is valid only for a variant, a version, etc. of a product. Continued changes encounter for new or improved products and variants.

Suppose that a model object describes interrelated objects at a moment during an engineering process. Development, variant creation, and correction actions by engineers in participating in that engineering process are considered as changes. The aim is an establishment of unified management of computer intelligence supported engineering processes including analyses of different purposes in recent modeling systems. Powerful but not intelligent change management is available in industrial modeling (e. g. CAD/CAM) systems to accept the proposed procedures as connected ones.

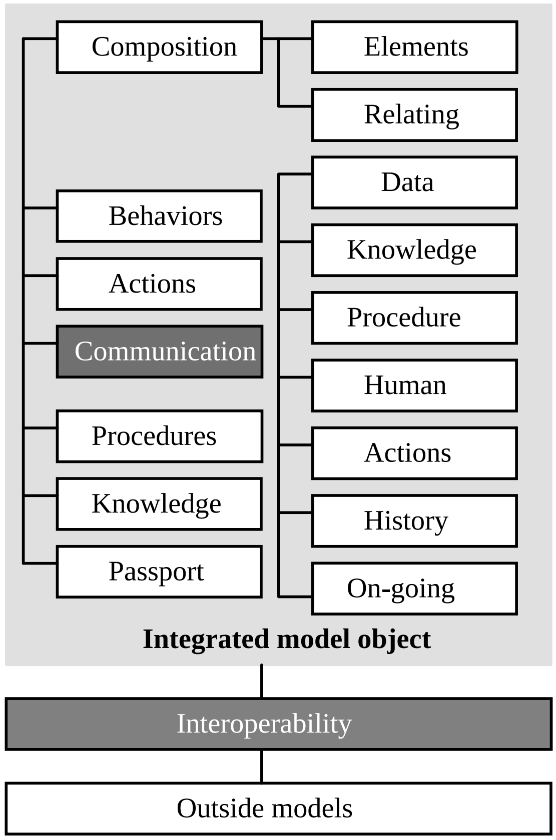

Fig. 1 General schema of object information

Model object descriptions are composed by parameters, behaviors, associative connections, knowledge, and adaptive actions. These elements rely on definitions of engineering objects, data descriptions, solutions, situations, circumstances, and modeling procedures [1].

Engineering processes fulfil design objectives. Any modeled object is characterized by several behaviors according to its content. The authors extended conventional application of behavioral models in order to cover as many design objectives as possible. It is assumed that any change of an engineering object may affect one or more behaviors. Engineering objects are parts, subassemblies, functional units, chemical, etc. processes, production equipment, manufacturing processes, etc. according to actual tasks in an engineering organization. Consequently, changes of an object and other objects in its affect zone may require repeated evaluation of behaviors. If a change modifies situations defined for behaviors, behaviors are undergone repeated evaluation. Because behavior is a design objective in itself, specification of behaviors may be also changed. This is why reverse of the above process is also applied. Behaviors are defined for situations composed by circumstances (Fig. 2).

Essential management of object changes can be followed in Fig. 2. Integrated model object receives information about accepted and proposed changes from interfaced humans, inside procedures, and outside world. Received and generated adaptive actions are first mapped as conditional ones in descriptions of relevant engineering objects. Then their effects on parameters and behaviors of other engineering objects are analyzed. This effect analysis generally generates adaptive actions as additional changes in the course of development of change chains. These newly generated changes are effect analyzed. This process is continued during the entire product development. In the meantime, accepted decisions are considered as final adaptive actions. Changes within integrated model object are executed except for changes that depend on changes attempted in outside world. Change attempts are accepted or rejected by the outside word. At the same time, new changes may be attempted from outside.

There is a question that how the above process will converge towards a final solution for product design. The right answer is that the process is under control of humans. Intelligent system visualizes consequences and allowed directions of new and new changes. At the same time, knowledge, associativities, and behaviors are defined and modified by humans according to the actual advancement towards final solutions. An intelligent system acts as an advanced navigator and not as a design automata. Engineers have much more chance than in conventional modeling to find a conflict free solution.

The above-discussed components are enough to a formal definition and establish of intelligent model objects. The manner of model object development in which modeled objects and knowledge related to it are built simultaneously, necessitates application of model objects created during engineering activities instead of predefined model objects.

4 Organized communication of changes

As it can be seen from the outline of change management in the previous section, main problem at decisions assisted by computer models is that the consequences of a change of a model describing several interrelated modeled objects extend to outside of a modeling environment constituted by the proposed model object. This enforced the development of engineering modeling systems towards extended enterprises during recent years. Another problem is that despite efforts to establish standardized reference models and application protocols, incompatible models even not modeled objects are to be interfaced.

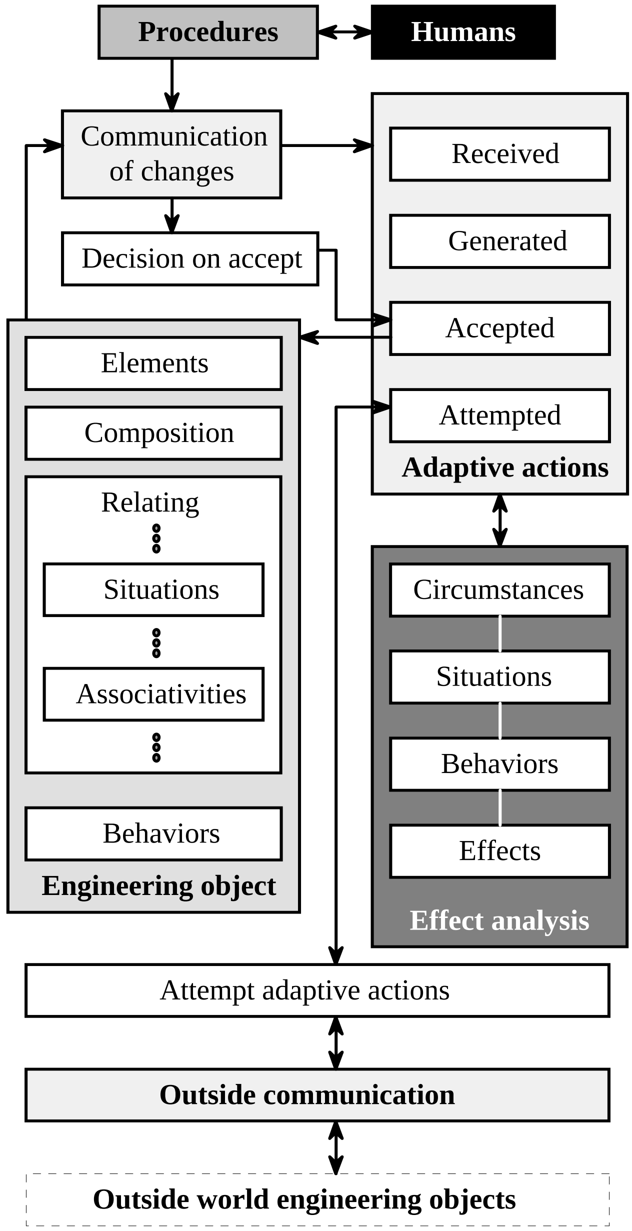

Fig. 2. Management of changes

The authors studied outside connections of a modeling environment and introduced the concept of affect zone. Objects to which a change of a modeled object has any effect are considered to be within the affect zone of that modeled object. Integrated model object as defined by the authors includes representations for a given set of modeled objects. Any other objects in the affect zone of these objects must be accessed from the world outside of the integrated model object.

Well-organized intelligent communication initiated by change information is intended to be a contribution by the authors to solve the above problem (Fig. 3). By using of generic object descriptions, instances of descriptive object entities, situations, associative connections, adaptive actions and behaviors are calculated. Objects, circumstances, and situations are identified for processing of change information according to Fig. 2. Associative connection definitions for identified model entities are grouped into inside, outside and unavailable ones. Following this, values for inside and outside associative connections are calculated and adaptive actions are generated. Effect analysis is done simultaneously according to Fig. 2. Unknown associative connections may also encounter. They can not be modeled but must be considered by the humans who control the actual engineering process.

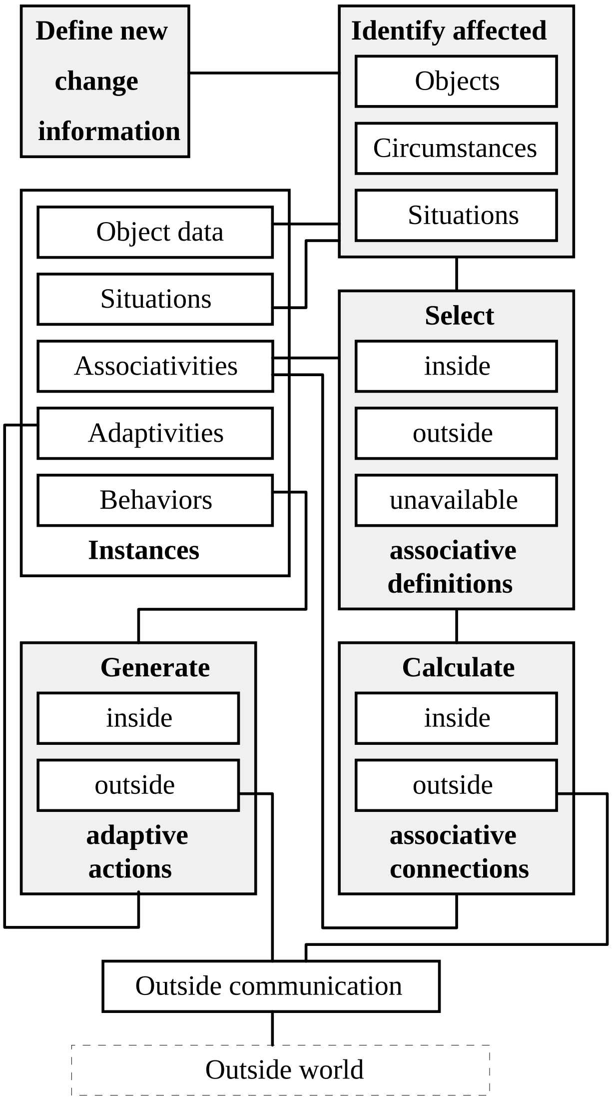

Fig. 3. Intelligent communication of changes

5 Combined Intent Driven Knowledge

One of the primary objectives of engineering systems development is more knowledge content of procedures, background data, and product data. During the eighties, knowledge based systems applied domain knowledge in rule-frame configurations. Recent industrial modeling systems attach corporate knowledge to model descriptions of engineering objects. Two objectives by the authors cover enhancements in knowledge content of product models and application of personal intent originated knowledge [1].

Decisions have more or less complex human background. The authors considered combined intent at knowledge based decisions. For example, a decision on a dimension of a part by an engineer who is responsible for it may apply knowledge also from scientists, standards, legislation, local instructions, decisions of engineers on a higher level of hierarchy, or customer demand. Engineers and other humans participating in this decision chain may apply high amount of knowledge collected from many other sources. Decision-making is controlled by combined intent of multiple humans. Any knowledge represents personal, corporate, and official intent and it is filtered by responsible human.

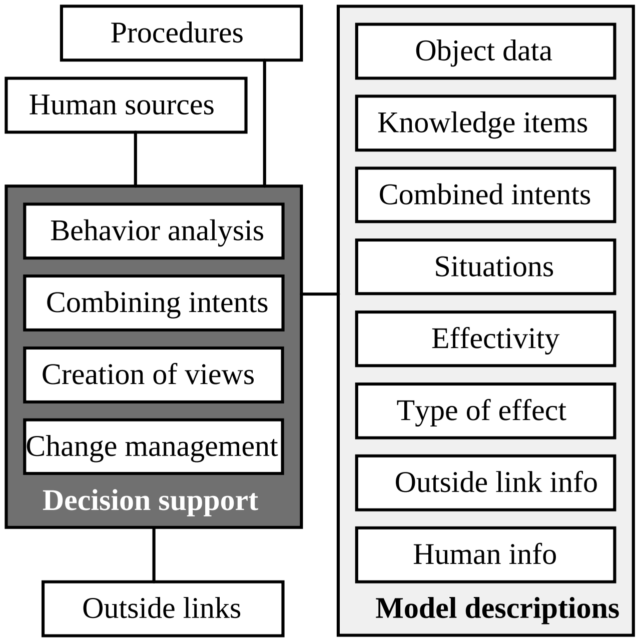

Fig. 4. Scenario for decision assistance

Combined intent based decision making is supported by behavior analysis, creation of views, combination of intents, and change management (Fig. 4). Processing is controlled by human sources and procedures. Outside world communicates through outside links. Conventional items of knowledge representations are extended by situations for behavior analysis, combined intents, effectivities for views, and types of effects. Additional elements are human originated and outside linked descriptions. Knowledge items are associative with modeled object items.

6 Shape Centered Object Descriptions

Most of products in the industry are composed by mechanical parts. At the same time, most of product information can be attached to shape descriptions.

Recently, structures of functions are described in product models. Functional structure is attached to shape structure. This offered a great possibility to implement the proposed intelligent decision assistance in shape modeling covering wide area of applications.

Fig. 5 shows logical connections between entities of shape models in recent industrial modeling. Part model entities act as elements in description of a modeled object. Relating geometric or form feature entities of parts in structural units (assemblies) and mechanisms for relative placing of parts and movement definitions by degrees of freedom between them constitute composition information. Relating attributes of shape and non-shape model entities by equations, rules and checks are represented in associative connection definitions.

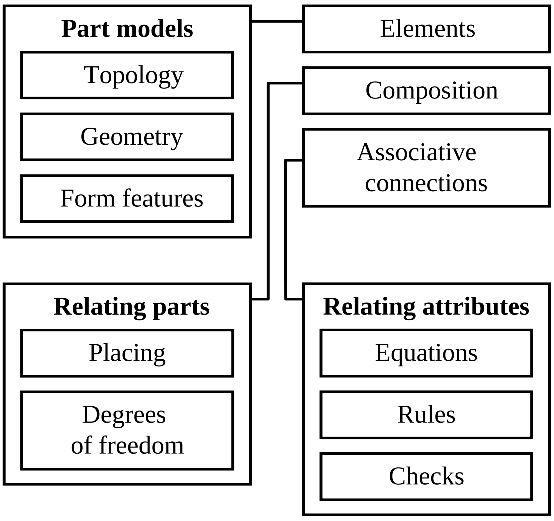

Fig. 5. Shape centered modeling

By now, sophisticated shape modeling in CAD/CAM systems has developed into unified boundary representation where topological entities connect surfaces and their intersection curves and in the boundary of a shape. Curves and surfaces, in other words geometrical entities are grouped in form features. They are also related to describe information about fixed and moving connections of parts in product model. Standardized application protocols are defined in ISO 13303 in order to establish well-organized product model information [7]. Non-shape information as materials, loads, manufacturing processes, marketing results, etc. has been integrated with shape information in complex product models. The authors decided analysis for application of object change management in shape centered object structures. A preliminary of this work was published in [4].

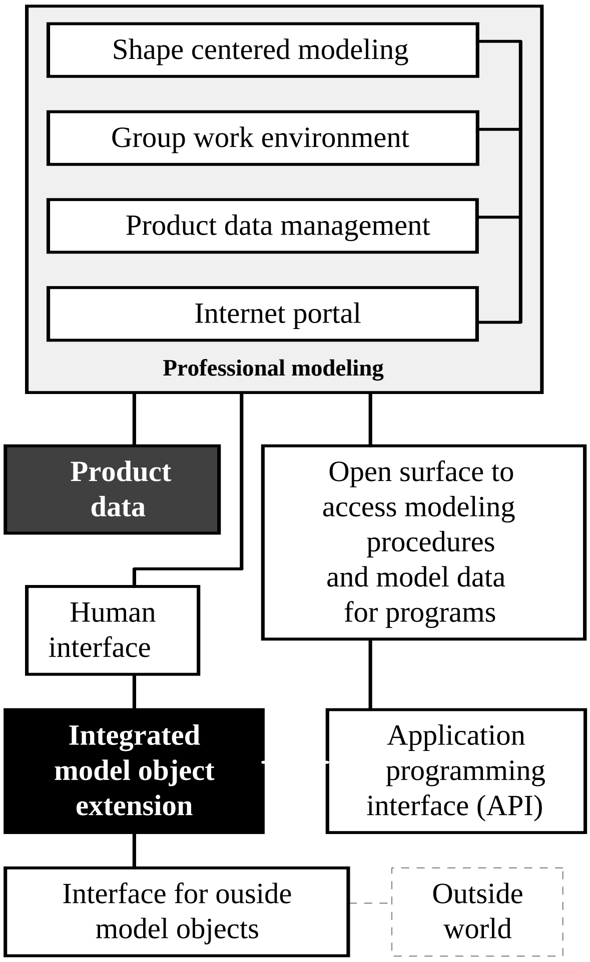

Fig. 6. Extended modeling system

7 Implementation and Future Research

Implementation of essential methods discussed in the above sections has been conceptualized in product lifecycle management as application specific extension (Fig. 6). Benefits of this solution are affordable system development, work of engineers in professional engineering environments, and application of existing product data systems. Industrial professional engineering modeling system consists of a comprehensive set of modeling procedures, model database with product data management (PDM), interface and navigation service, and Internet based group work procedures. Application programming interface (API) supports development of corporate extensions in the form of new programs written in own development environment of the modeling system.

The proposed modeling is just before implementation in an experimental environment according to Fig. 6. In the next future, two main groups of tasks have been composed by questions in analysis of integrability and description capability of the proposed modeling.

8 Acknowledgments

The authors gratefully acknowledge the grant provided by the OTKA Fund for Research of the Hungarian Government. Project number is T 037304.

9 Conclusions

A contribution to knowledge based product modeling is introduced in this paper. Management of changes of engineering objects during creation of product models is focused as one of the problematic areas in recent product lifecycle management. For the purpose of highly integrated modeling, the authors proposed application of integrated model objects in their cited earlier works. Main contributions of this paper are concluded from needs for object change, change communication, and knowledge in recent modeling. They are subsets to be handled, effect analysis for changes, associative connection definition driven organized communication of changes, combined human intent based knowledge definition, and implementation for shape centered engineering objects in professional product lifecycle management systems. Demand for future research has been identified in analysis of integrability and capability of description of the proposed modeling. These are needed to establish an experimental system, in which virtual tests answer the suitability of the proposed method for decision making in simulated situations. Main benefits are anticipated in enhanced assistance of quick but high quality decisions in product related engineering.

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