Product Definition in Virtual Space Using Background information at Description of Engineering Objects

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Abstract: - Current technology of engineering has reached a level where lifecycle product information, comprehensive sets of model creation procedures, product data management, and Internet based communication environment serve integrated group work of engineers. It is inevitable, that the next main phase of development of the digital product definition is enriching content of product model in order to more intelligent decision support at product development. In this paper, the authors introduce a new methodology as a contribution to future intelligent modeling systems. Paper starts with a discussion on possibilities of enhanced product definition as a result of extension of current professional industrial modeling systems. Following this, a method is given for the description of associative features in product model. Next, description of associative features, extension of modeling by background content, as well as extension of product model for content constitute the main sections of the paper.

Key-Words: - lifecycle management of product information, product modeling, handling changes at product development, human – computer interaction in engineering, information content in product model.

1 Introduction

One of the main conflicts in product modeling has been emerged by extensive development of product models. In the practice, high number of modeled engineering object and object relationship definitions result more and more difficulties at the handling of large models.

In this context, term engineering object applies for any entity that carries useful information during the lifecycle engineering for products. Beyond components and structures of products and manufacturing processes, entities for specification, analysis results, and knowledge are also considered as engineering objects. Consequently, a new decision for a component of a product, for example, must be coordinated not only with other components and their structures, but also by specifications, analysis results, and knowledge items. Present practice of industrial product modeling is restricted to information representations about engineering objects and do not support the above coordination that would require information content in product model.

High level assistance of decision making on engineering objects and the related simulation require sophisticated information about dependencies for the calculation of attributes and parameters of modeled objects and the valuation of consequences of proposed or accepted new values of those attributes and parameters. This paper introduces a new method for the definition and relating information content in product model.

As a contribution to solution for the problem that is caused by the high number of unstructured dependencies amongst engineering objects in product model, the authors developed a structured dependency description. For the definition of an engineering object or its attribute, the search space of dependencies is restricted to an actual subspace. Actual dependencies are selected for the propagation of changes in this subspace. For this purpose, the concept of engineering object parameter dependent change affect zone (CAZ) was introduced. Decision on engineering objects is assisted by description of information content for dependencies.

In this paper, the authors introduce a new methodology as a contribution to future intelligent modeling systems. Paper starts with a discussion on possibilities of enhanced product definition as a result of extension of current professional industrial modeling systems. Following this, a method is given for the description of associative features in product model. Next, description of associative features, extension modeling by background content, and extension of product model for content constitute the main section of the paper.

2 Enhanced Product Definition

Two main problem areas in product modeling are produced by unstructured dependencies and the information based description in product models.

Automated survey of high number of actual associative connections is impossible in current product modeling mainly because it cannot provide transparent structure of associative connections. Manual tracking of connection chains in current modeling proved as an unreal task and it is one of the main sources of errors and mistakes. Numerous research projects resulted partial achievements in connection with the proposed modeling (Fig. 1). For example, definition of product model was recently improved by procedures and model entities for capitalization of knowledge, recognition and creation, and relating of features, and assessment of performance of engineering objects.

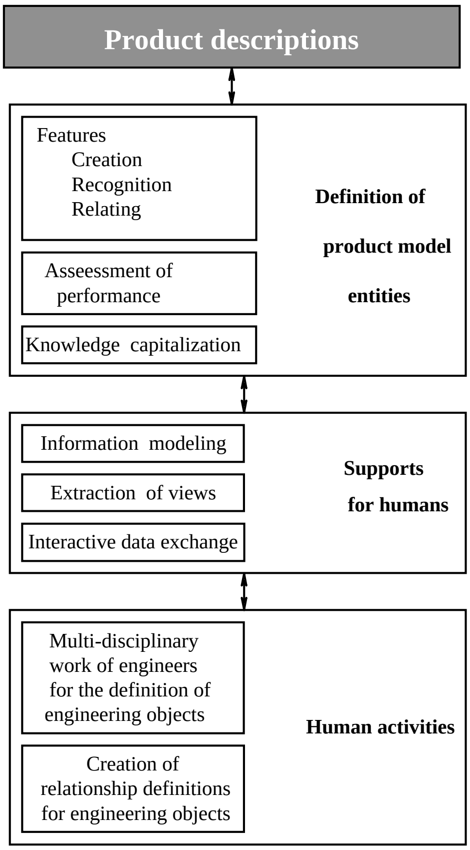

Fig. 1. Issues of the cited research

Information modeling is communication between engineering and product modeling. IDEF1-based process-oriented information modeling methodology is proposed in [1]. The IDEF0 process model is integrated with the enhanced IDEF1 information model. The result is easy identification and analysis of information requirements. Recent method is extraction of application specific product data subsets from large and very complex product models in the form of views. An integrated design framework is shown in [2] where the product model used by the process planner is extracted from the global product model by filtering.

Complex shape of a mechanical part is constructed in the course of sequence of shape modifications by form features. When a shape was constructed by a different system or shape modification information is unavailable, sequence of shape modifications should be reconstructed by feature recognition. In [3], graph and hint based methods, convex hull decomposition, and volume decomposition-recomposition techniques are introduced.

Numerous recent works show the actuality of research in knowledge based product model related issues. In [4], an approach to definition and mapping of knowledge, based on the point of view of an expert in manufacturing is discussed. The authors of [4] propose tools and models for knowledge capitalization.

Research in associative connections of engineering objects focuses onto partial problems of product models and cannot provide a general solution. Paper [5] presents associative assembly design feature as a new type of features. This new feature allows associations between parts that have not been defined geometrically, between geometric entities defining interfaces between parts, and between part geometry and intermediate geometry used to define a part. Extension to traditional assembly feature properties allows product architectures to be defined using features.

Despite process orientation of product data management (PDM) systems, support of flow of product information is weak in current engineering modeling systems. In paper [6], interfacing knowledge oriented tools and CAD application is identified as a technical gap for intelligent product development. The authors of [6] consider definition of associative features in the form of self-contained and well-defined design objects as essential for high-level reasoning and the execution of decisions.

Finally, product modeling requires high level of multi-disciplinary activities with participation by high number of areas of expertise. Paper [7] emphasizes multi-disciplinary character of work in early stage of aircraft design. Large variety of specialized tools must be compatible. Otherwise, interface problems may be emerged.

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The authors of this paper did several projects in product modeling. The most relevant ones that are considered as preliminaries of the work reported in this paper are in the following (Fig. 2). Improvements were proposed for industrial modeling in CAD/CAM systems towards more intelligent and human centered engineering processes. The proposed methods supposed integration of product data management (PDM) with product modeling.

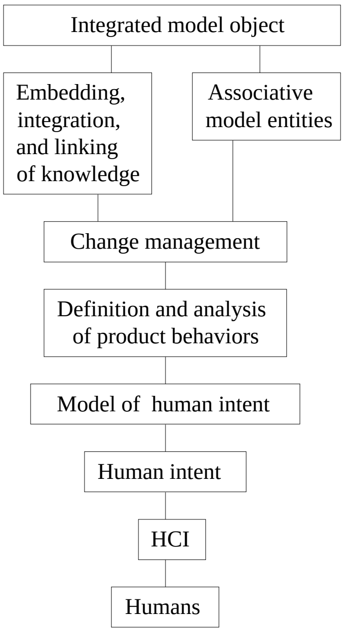

Fig. 2. Relevant issues

In order to establish an enhanced human-computer interaction (HCI), the authors of this paper analyzed then modeled human intent [8]. A method was elaborated that can consider intent of any person who may influence on a decision. The knowledge is defined, filtered, and accepted for this purpose in accordance with human intent [9].

Methods for were published for associative engineering object definition and product behavior analysis driven management of product changes in [10]. In order to achieve a complex model object for closely connected engineering objects, the authors introduced the concept of integrated model object (IMO) [11].

As a preliminary analysis for the preparation of integration of the above methods in modeling that is applied in recent CAD/CAM systems, the authors of this paper surveyed problem solving techniques available in these systems for model-based engineering [12].

Although classical information oriented modeling uses multilevel structures for partial models such as form feature information model in the STEP standard for product modeling [13], a new overall approach to leveling was necessary to be developed.

The authors emphasized the importance of engineering process driven development of product model information in [14]. They identified typical groups of engineering processes that must be served by sophisticated models of products in industrial applications. Collaboration of engineers is established by collaborative procedures and Internet portal.

For the future development of engineering systems, the success in the implementation of computational intelligence seems to be critical. In [15], a hybrid computational intelligence approach is introduced and discussed. This approach integrates Fuzzy C-Means and genetic algorithms.

At the application of advanced knowledge based methods, the computational time is important, even if high computational performance of the actual computer system. In [17], fast and cooperative modular neural networks are combined in order to achieve higher performance of a detection process.

Information technology intensive engineering requires appropriate education in Internet environment where close connection can be established between education and industry. In [18], a route was defined towards knowledge based society development. Projects were initiated in order to gain appropriate experience in this area.

3 Description of Associative Features

Advanced product definition applies single model for product variants and the same model is applied for the development by continuous improvement of product and activities during the product lifecycle. Numerous effects on engineering objects and their connections constrains product by strategic decisions, standards, and legislation. Lifecycle of a product in the engineering system has been extended to the end of successful recycling of the product. Recycling must be considered at the definition of materials in a product. The above circumstances resulted high number of relationships among engineering object considering lifecycle of the product. Current knowledge based methods focus on definition of closely connected parameters of critical engineering objects. This helps in local modifications in a large model. However, global consequences of changes can not be evaluated by using of conventional knowledge based methods in engineering. Consequently, global effects of changes should be analyzed in typically large product models.

As a first step towards development for intelligent modeling, an organized structure for dependencies is to be established. In order to enhance the ability of current industrial product modeling systems to assist engineers in the survey of dependencies, the authors proposed a method for organized description of dependencies amongst engineering objects.

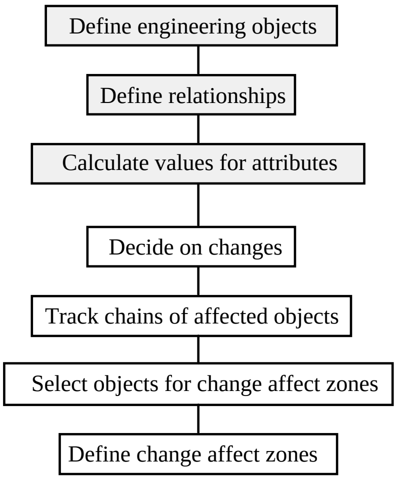

Fig. 3. Change management

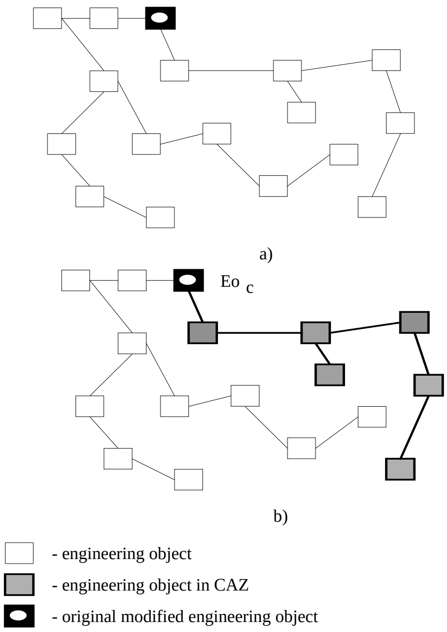

Fig. 4. Organized description of dependencies

The authors made tracking of chains of affected engineering objects easier by the introduction concept change affect zone (CAZ) (Fig. 3). CAZ is defined for a parameter or an attribute of an engineering object and it includes engineering objects affected by the changed engineering object.

In the proposed modeling, dependency structure across a product model is represented as a graph where nodes represent engineering objects represented by an actual parameter, parameter set, or attribute and arcs represent associative definitions (Fig. 4). CAZ of an engineering object parameter defines a restricted search space in the graph as possible subspace of consequences of its change. Information content includes origin and background for a dependency and it depends on the engineering task, the responsible and influencing humans, and the environment.

In Fig. 5, main groups of product model entities and their associative connections are interrelated. Elementary product entities are applied as construction elements of parts and are connected as elementary shapes, etc. A component is associative with elementary entities in its structure, other components, entities for its analysis, and processes for its manufacturing. This approach is suitable for both current product modeling and the modeling proposed by the authors as its extension. Models are defined and modified by knowledge driven and human controlled modeling procedures.

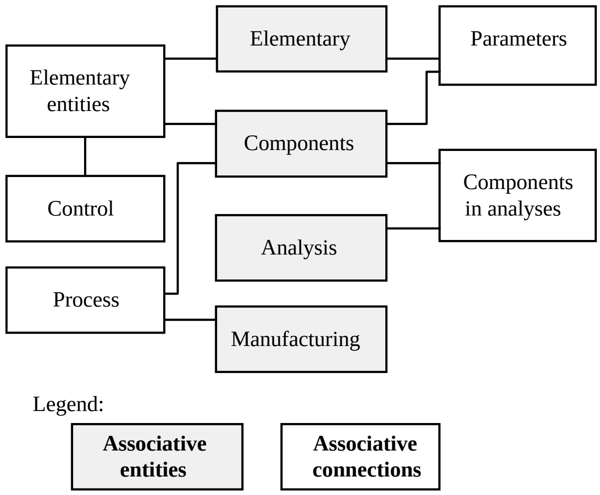

Fig. 5. Associative connections amongst elements for the construction of product model

For the purpose of definition and processing of human intent, information content, and associative connections, new procedures were necessary to define (Fig. 6). In order to establish suitable product model extension for these procedures, engineering object behaviors and situations, [11], multiple human intent filtered, and embedded, integrated, or linked knowledge, [8], [9], change affect zone (CAZ), structure of associative connections, and adaptive actions to carry modification information [10] are to be described.

An attribute of an engineering object is often affected through several associative connections. A node in the structure of dependency graph represents an intersection of different change chains for different initially changed attributes. It is obvious that an attribute may have different connections (Fig. 7). A connection may receive

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different change attempts along different change chains. Status of a change attempt in a change chain may be “under revision”, “under discussion”, “argued”, or “decided”. Different values of attributes for product variants and solution alternatives are also mapped to nodes.

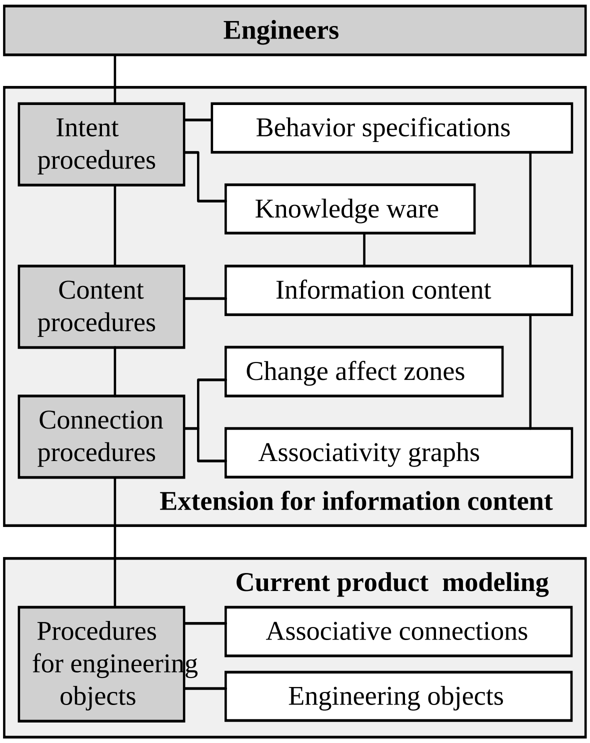

Fig. 6. New procedures and model units

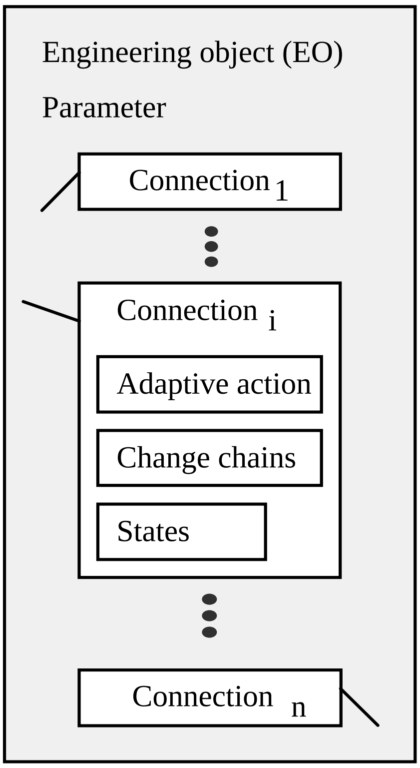

Fig. 7. Node in the dependency graph

4 Interactions on the Human Interface

There are some characteristics of human-modeling procedure processes that decrease the effectiveness of the human-computer communication. Some of them are summarized in the following.

Product model entities are representations of information. Product model includes data for engineering objects and relationships among engineering object data in the form of logical relations, equations, diagrams, and tables. Procedures use information to generate new information.

Items in product models considered as knowledge really represent information. Rules, checks, and controls are commonly included in product models. These entities represent some synthesized information so that formally can be considered as knowledge. However, this knowledge that usefully completes information is not appropriate for the purpose of information content. These entities are suitable for handling local, separated problem in conventional expert systems. However, engineer is thinking in situations and produces interrelated partial decisions. A partial decision frequently changes depending of numerous factors.

Human controls the work of procedures that generate entities in product models by exchange of information, in graphical or alphanumerical form. During interaction, human thinks about possible solutions for a problem. As a result, human establishes how problem can be solved and why a means of solution is selected. Human can not record these contents of information in product model. Whereas, these results remain in the brain of human who applies them at creation of data for control of model information creation procedures that is to be controlled.

In order to include information content in product model, a restricted modeling of the human thinking process just for the purpose of information content based modeling was developed by the author of this paper. Relationship between this model of human thinking process and the product modeling environment is summarized in Fig. 8. In the scope of an actual thinking process, human develops a solution in the course of interdependent decisions on relevant engineering objects. Solution in this context is a result of engineering work that is not practical to divide because of inside close connections. Result of the human thinking process is communicated with model creation procedures for the relevant engineering objects in CPM. These procedures generate new or modified sets of data for the engineering objects.

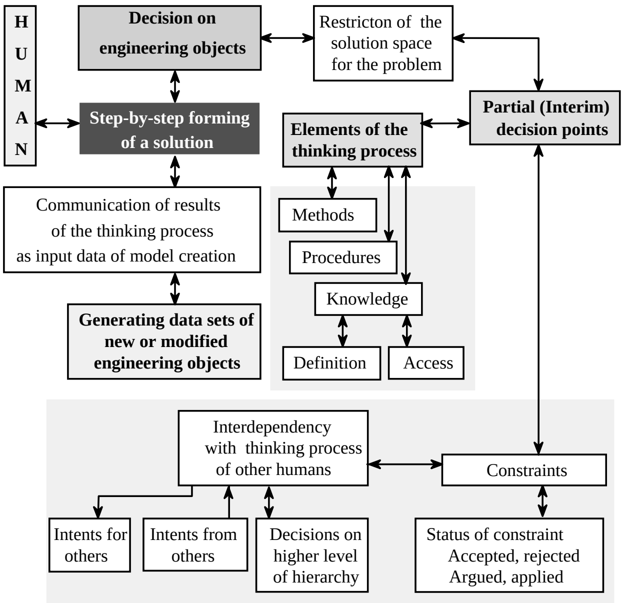

Fig. 8 Human thinking process in engineering

Human thinking process for a solution is divided into its elements and partial decision points are defined. Human utilizes problem solving methods and procedures, and defines and accepts knowledge at each element of the thinking process. Interdependencies with other humans are realized through received and defined constraints. In the proposed modeling, constraint is defined as human intent. Human also receives decisions from higher level of hierarchy, in the form of constraints. Constraint may have accepted, rejected, argued, or applied status. In case of status applied, the constraint is previously decided and the responsibility is held by the decision-maker. Decisions from higher level of hierarchy may be argued according to the valid measures in an engineering environment.

Actually, intent record describes human effort for a value-adding activity and it can be considered as an intelligent history of model construction that is completed by a simplified description of human thinking process. Definition of human intent for information content based product model includes information about authorization, characteristics of the intent, simplified thinking process, and the content itself (Fig. 9). Human communicates with intent definition through authorization and access information. Characteristics of intent are purpose, type, and status of the intent and status of the human. Fig 9 shows representative sets as examples for a possible choice of application oriented characteristics. Intent definition carries decisive information content from authorized human. Authorization is coordinated for engineering projects and intent definitions. Motivation of the communicated intent informs us about why the thinking process is initiated. Type of intent refers to its purpose. Besides definition of attributes for engineering objects, intent may serve a strategy, a counter-proposal, an application of an engineering object, etc. Status of intent informs about its strength. It varies from the strong standard to the weak maybe. Status of human informs about the strength of the human who defined the intent at a relevant decision. Roles of humans in projects within a group work organization are listed in the choice of status of human.

5 Extension by Background Content

The authors recognized current information based product model in the industrial PLM systems as classical one. Elements and units in a classical product model are defined for engineering objects. Definition of engineering objects and construction of product model are done by engineering object and structural information specific modeling procedures. An obvious way to enhance information content in the classical product model would be the application of one of the well-proven knowledge representations. However, in classical product models, knowledge entities are also stored as information and the human who define those stores information content in mind.

Classical product model (CPM) includes information representations of engineering objects for a product and its engineering activities and does not include content background of the modeled information. The classical attribute refers to an age of product modeling achievements of that has become classical. It is also a tribute to people involved in significant research and development in this area. We found CPM theoretically and methodologically complete and well-established system that is appropriate to accommodate information structures that are produced by classical product model generation procedures under the control of information content based model. Creation, relating and modification of CPM is defined as the classical product modeling.

Process of product definition for classical product model is outlined in Fig 10. Human is in interaction with procedures that generate data structures for the classical product model (CPM). Human communicates result of thinking process for the definition of engineering objects with model creation procedures. Procedures generate and relate

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data sets for model entities representing engineering objects.

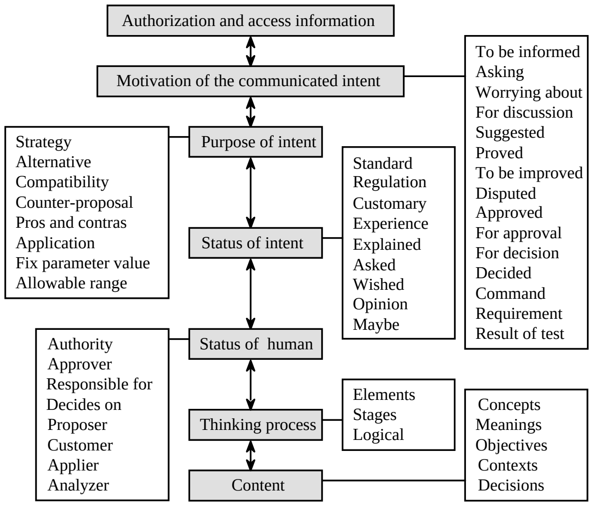

Fig. 9 Composition of intent definition with examples

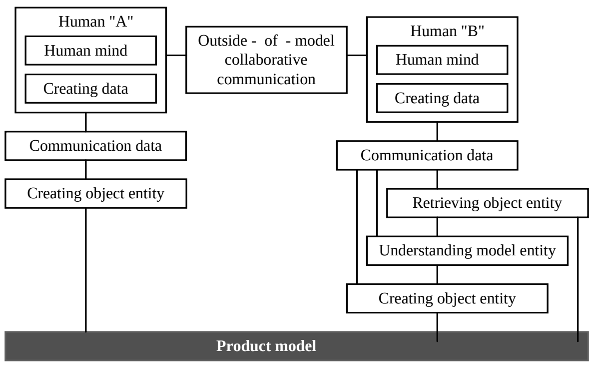

Fig. 10 Schema of the classical information based product modeling

Engineer controls model creation process by data communication to decide on attributes of new engineering objects and on revision of earlier defined model objects. Because information content is not available in the product model, outside - of - model collaborative communication between engineers fills the gap. Although this communication may be enhanced by advanced annotation, it is only an auxiliary communication instead of communication of information content.

In case of information content based modeling (Fig. 11) human “A” defines intent. At the same time, this human may be allowed to define information content for the other four levels of the information content based sector of product model as direct intervention. Anyway, the normal route leads through the five levels of content definition. Control of data of engineering objects is encountered as execution of result of decisions.

When direct intervention is necessary in the information based product model, human can control the input of data generation directly. The problem is that in case of omitting certain even all levels in the information content based sector of product model, the chain of content information is interrupted. Human “B” retrieves and applies information content together with model data.

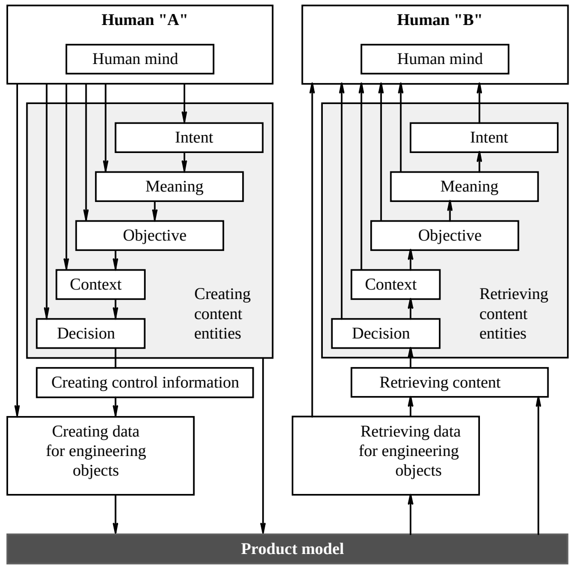

Fig. 11 Content based communication of humans

In order to achieve an efficient decision assistance, the authors decided to complete the classical data oriented product model by information content oriented model sector. They recognized information content based product model in the course of analysis of human thinking process in engineering decisions, definition of information content, and assessment of information content to enhance description of engineering objects and establish a possible structure of information content in product model.

The authors analyzed the above problem and defined an information content based extension to the classical product model. In order to achieve this, the authors studied the present information oriented product model, analyzed modeling methods and model communications, and assessed human activities and human-computer communications (Fig. 12). Following this, they recognized data based product modeling by the analysis of model information and structure, and assessment of description of engineering objects and human activity at model creation. As a main result, they recognized conflict of information orientation as information communication between the information oriented modeling procedures and information content oriented human. In other to prepare communication between the information and the information content based models, a new multilevel information structure was defined.

Eventually, content information assists effective communication between engineers and data oriented modeling procedures. Content information enough for explanation and evaluation of modeled objects and their environment must be represented in product model for modeling tasks. Content information must be enough to save compliance of product model information with intent of responsible engineers. Knowledge from all relevant sources must be defined and involved as information content.

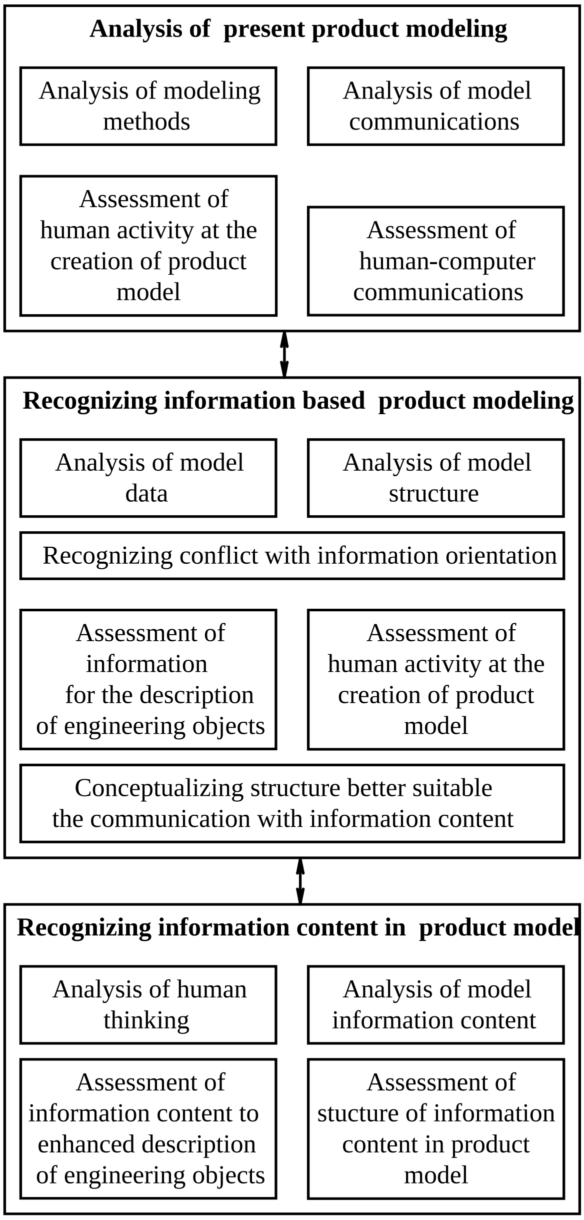

Fig. 12. Way to modeling of information content

The proposed product model is outlined in Fig 13. It consists of information and information content based sectors. Classical product model was extended by a new multilevel structure entity that pointed to entities in well-proved data oriented product models in present industrial engineering modeling systems. This extension was defined to communicate with information content based sector that controls model information in the information based sector.

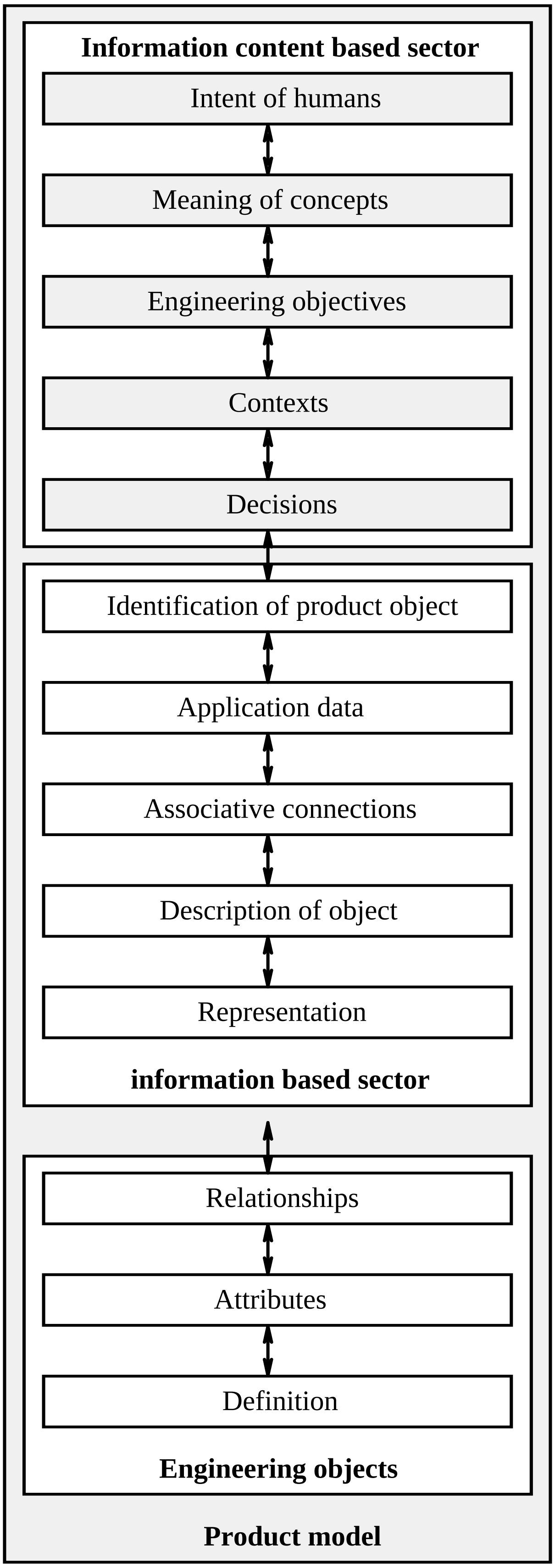

Fig. 13. The proposed product modeling

In an information based product model, engineering objects are defined, attributed, and related. In the information based sector of the proposed model, identification of engineering object points to application data mainly for the purpose of specification of essential design information. Detailed description of an engineering object is preceded by definition of its associative connections with other engineering objects. Engineering object is described by its attributes. Representations are mapped to attributes according to demand posed by the described engineering objects.

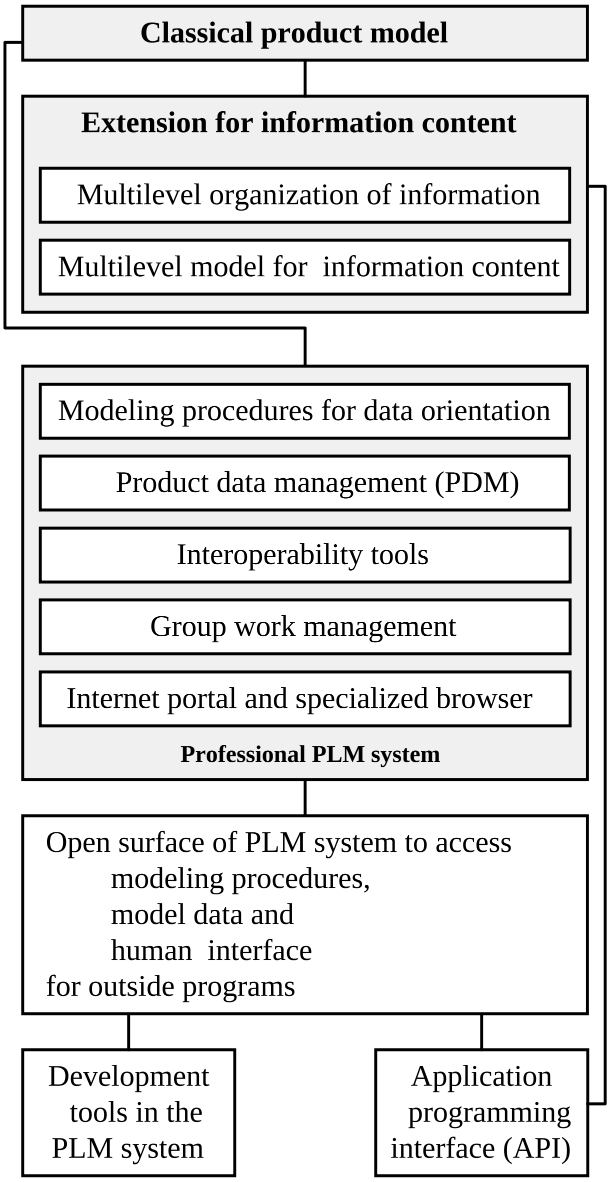

Fig. 14. Implementation in PLM systems

In the multilevel structure of the information content oriented product model (Fig. 13.), definitions of human intents are followed by explanation for the meaning of the concepts that are applied by the humans acting as sources of intents. Making, revising, and reproduction of interrelated decisions on engineering objects need information about meanings of concepts and contexts of the decided items, and engineering objectives.

6 Some issues in Information content based product model

Content of information to be included in the product model about engineering objects should be based on answers to questions on background of decided engineering object information. The question about the origin of decision on engineering objects can be answered, as it is required by influencing humans. Intent of influencing humans should be recorded together with the agreed hierarchy of them. Definition of intents includes concepts. Meaning of these concepts is the next element of the modeled information content. Engineering objects should match with engineering objectives. These objectives are specified directly by influencing humans or they come from human intent definitions. An engineering object is defined in the knowledge of information about engineering objects that are in relationship with it. These relationships are generally coming from human intent and engineering objective definitions and their direct definition is possible. For this purpose, contextual and non-contextual dependencies are to be modeled. Utmost purpose of information content is support of decision making engineering activities. Content is necessary to know about decisions because it is the basic concern of control engineering objects in the product model space. Decision changes engineering objects. Consequences of these changes are change of other engineering objects that are in direct or indirect dependence connection with the originally changed engineering objects.

7 Extension of Product Model for Content

As it was emphasized above, well-proven PLM technology is in the background of implementation. As a conclusion of the above detailed modeling, joint application of organized dependencies and modeling of information content as two main extensions is necessarily. Extensive modeling software tools in PLM systems are utilized (Fig. 14). Product modeling procedures, model data structures, and graphic user interface can be made accessible for programs in the information content based extension. Access path can be built through standard application programming interface (API). Other functional units of PLM systems such as management of product data in case of different modeling systems, interoperability to enable data exchange with non-integrated modeling systems, as well as group work and Internet portal communication are equally important at the implementation.

An experimental environment is under continuous development at the Laboratory of Intelligent Engineering Systems (LIES) of the Institute of Intelligent Engineering Systems, John von Neumann Faculty of Informatics, Budapest Tech. The purpose of this system is research in information content based product modeling. LIES has been equipped with leading industrial PLM, intelligent computing, and mathematics software.

8 Conclusion and Future Work

A new methodology was given for the development of product models towards more intelligence at coordinated making of high number of decisions on engineering objects during development of products. The demand for an organized structure of dependencies and the need for a product model extension by content of modeled information were two initial recognitions. Starting from these recognitions, a graph was defined for dependencies in order to facilitate tracking of effects by change of an engineering object on other engineering objects. Multilevel structures were applied for the organization of existing information structure and the new information content in professional industrial product models.

Intent record is used to describe human effort for a value-adding activity and it can be considered as an intelligent history of model construction that is completed by a simplified description of human thinking process.

The proposed product model consists of information and information content based sectors. Classical product model was extended by a new multilevel structure entity that pointed to entities in well-proved data oriented product models in present industrial engineering modeling systems. This extension was defined to communicate with information content based sector that controls model information in the information based sector.

An engineering object is defined in the knowledge of information about engineering objects that are in relationship with it. These relationships are generally coming from human intent and engineering objective definitions and their direct definition is possible.

Future work must be concentrated on the definition and relating the new model entities and the procedures for the control of engineering objects by the definition of human intent originated content of the modeled product information.

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References:

[1] P-H. Chen, C. Wana, R. L. K. Tionga, S. K. Tinga and Q. Yangb, "Augmented IDEF1-based process-oriented information modeling," in *Automation in Construction*, Volume 13, Issue 6 , November 2004, Pp. 735-750

[2] H. Paris and D. Brissaud, "Modeling for process planning: the links between process planning entities," *Robotics and Computer-Integrated Manufacturing*, Volume 16, Issue 4 , August 2000, Pp. 259-266

[3] J. J. Shah, D. Anderson, Y. S. Kim and S. Joshi "A Discourse on Geometric Feature Recognition From CAD Models," in *Journal of Computing and Information Science in Engineering* Journal of Computing and Information Science in Engineering -- Volume 1, Issue 1, March 2001, pp. 41-51 Volume 1, Issue 1, pp. 41-51

[4] J. Renaud, "Improvement of the Design Process through Knowledge Capitalization: an Approach by Know-how Mapping," in *Concurrent Engineering*, Vol. 12, No. 1, 25-37 (2004)

[5] Y.-S. Ma, G. A. Britton, S. B. Tor and L. Y. Jin, "Associative assembly design features: concept, implementation and application," in *The International Journal of Advanced Manufacturing Technology*, Volume 32, Numbers 5-6 / March, 2007, pp. 434-444

[6] Y.-S. Ma and T. Tong, "Associative feature modeling for concurrent engineering integration," in *Computers in Industry*, Volume 51, Issue 1, (May 2003), pp. 51 – 71

[7] C. Ledermanna, C. Hanskeb, J. Wenzelc, P. Ermannia and R. Kelm, "Associative parametric CAE methods in the aircraft pre-design,"*Aerospace Science and Technology*, Volume 9, Issue 7 , October 2005, pp. 641-651

[8] L. Horváth and I. J. Rudas, "Human Intent Description in Environment Adaptive Product Model Objects," in *Journal of Advanced Computational Intelligence and Intelligent Informatics*, Tokyo, Vol 9, No.4, pp. 415-422, 2005.

[9] L. Horváth, I. J. Rudas and C. Couto, "Integrationration of Human Intent Model Descriptions in Product Models", in *Digital*

Enterprise - New Challenges Life-Cycle Approach in Management and Production,: Kluwer Academic Publishers, 2001, pp: 1-12.

[10] L. Horváth, I. J. Rudas, J. F. Bitó and G. Hancke, "Intelligent Computing for the Management of Changes in Industrial Engineering Modeling Processes," in *Computing and Informatics*, Vol. 24, 2005, 1001–1013. [11] I. J. Rudas and L. Horváth, "Process Oriented Engineering Using Highly Integrated Adaptive Computer Descriptions," in proc. of the *32 th Annual Conference of the IEEE Industrial Electronics Society, IECON 2006***,** Paris, France, 2006, pp. 3568-3573.

[12] L. Horváth and I. J. Rudas, "*Modeling and Problem Solving Methods for Engineers* ", ISBN 0-12-602250-X, Elsevier, Academic Press, 2004, p. 330

[13] Ricardo Jardim-Goncalves, Nicolas Figay and Adolfo Steiger-Garcao, "Enabling interoperability of STEP Application Protocols at meta-data and knowledge level," *International Journal of Technology Management*, Volume 36, Number 4, pp. 402 – 421, 2006.

[14] I. J. Rudas, L. Horváth, "Emphases on Human Intent and Knowledge in Management of Changes at Modeling of Products," in *WSEAS Transactions on Information Science and Applications*, ISSN 1790-0832, Volume 9, Number 4, 1731-1738 (2006)

[15] A. G. Di Nuovo, V. Catania, M. Palesi, "Genetic Learning of Fuzzy C-Means Classifier System," in *WSEAS Transactions on Information Science and Applications*, ISSN 1790-0832, Volume 9, Number 3, 1609-1616 (2006)

[16] H. M. El-Bakry, N. Mastorakis, "A New Approach for Fast Face Detection," in *WSEAS Transactions on Information Science and Applications*, ISSN 1790-0832, Volume 9, Number 3, 1725-1730 (2006)

[17] S. Impedovo, "Information Communication Technologies: in support of knowledge-based society development. Some experiences at the University of Bari, in *WSEAS Transactions on Advances in Engineering Education*, ISSN 1790-1919, Volume 3, Number 2, 69-74 (2006)