

# Human Thinking Driven Object Generation at Model Based Product Definition

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***Abstract:** Quick development of product model based engineering resulted object modeling systems where arbitrary contextual product objects are created and applied in group work. Modeling software supports integrated modeling of a product by different engineering areas including mechanical, electrical, electronic, human, environment, and other objects. The authors recognized a possible way for the development of these systems towards deep modeling of human intent in the form of embedded knowledge in product model. In this paper they introduce their contribution to these efforts by a content based extension to current product modeling systems. After an introduction on the definition of human influence on product model, communication within group of engineers at product modeling is analyzed and content based product definition is explained and compared. Following this, essential process of the proposed content based product modeling is explained and discussed. Finally, future work and possible implementation are outlined.*

***Keywords:** Product modeling, content based product definition, human influence on product model definition, human intent based product model*

## 1 Introduction and Background

Implementation of paradigm product lifecycle management (PLM) changed the work of engineers. They build and apply a highly integrated product model that serves engineering activities during the full lifecycle of a product from the first sketch to the successful recycling. As in many other similar cases, the change for PLM has generated new problems in engineering. Highly integrated product models are often too complex for human decisions at industrial product development processes. High number of entities for parts, assemblies, simulation results, manufacturing processes, equipment control programs, and other engineering objects are arranged in hard to outline structures. Relationships are defined in product objects or as separate entities in product models. One of the main achievements in current modeling is highly flexible, easy and quick product

object definition. However, utilization of this achievement would require much more capabilities for tracking of affects of an entity change on other entities that current modeling systems have. Product model acts as a medium in communication amongst remotely situated engineering workplaces. In order to fulfill this purpose, current product model must be developed towards better representation of human thinking process considering strength of intent of each affecting human in the future. The authors recognized the above problems. They proposed an extension to the currently prevailing product modeling in order to enhance model representation capabilities for the support of human intent based decision making during development, manufacturing, and application of products.

The above recognitions inspired the authors to make a research in human influence at engineering modeling, including more intelligence in engineering systems, and including background of decisions in product model. Most important preliminaries of the reported research are as follows. The authors of this paper analyzed modeling methods and models in order to reveal functions, relationships, and human-computer interactions in current product modeling practice [2]. Model of human intent was developed in close connection with grouping of model entities according to their associative connections in environment adaptive product model objects [3]. An organized description of engineering object behavior definitions is proposed in [4]. Management of product model changes [5] and its human intent and knowledge management aspects [6] were also discussed in earlier works by the authors. The research for a new content based product model is based on the above cited results.

The topic of this paper was introduced as oral talk in the 2010 IEEE International Conference on Industrial Technology (ICIT 2010), Viña del Mar, Valparaiso, Chile, in March, 2010 [1]. This conference was a main event of the IEEE Industrial Electronic Society with worldwide participation of internationally recognized leading researchers just after the terrible earthquake. The specific conference theme this year was improving performance and efficiency through industrial technology. One of the purposes of the talk was to join to this theme.

Several most relevant of recent works are cited in the following. Authors of [7] emphasize the personal and organizational nature of knowledge and propose a new method for its handling. In [8], personalization and codification are shown in the development of a multidisciplinary framework. The authors of [9] propose tools and models for knowledge capitalization. Multiple expert source is a more feasible alternative as it is proposed in [10]. Research in [11] introduces the product lifecycle aspect and the feature principle in a new distributed database and considers knowledge base modeling approach for concurrent design. In paper [12], interfacing knowledge oriented tools and computer aided design application is identified as a technical gap for intelligent product development. The authors of [12] 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. Content based modeling by the authors of this paper considers

classification by Russell Ackoff. Ackoff classified content of the human mind into five categories [13]. These categories are data, information, knowledge, understanding, and wisdom.

In this paper, an introduction to enhanced human influence towards more intelligence in engineering systems and change for indirect knowledge definition serves grounding of the main concepts. Following this, developing strategies for human control on engineering modeling are discussed such as processing of human influence, extracting information content at object definition, as well as communication in current and in the proposed product modeling. As an additional key issue, process of the proposed content based product modeling is explained and discussed. Finally, future work and possible implementation are outlined.

## 2 Definition of Human Influence on Product Model

One of the classical problems in product modeling is human control on the increasingly automated model definition processes. Figure 1 summarizes the scenario of the proposed content based modeling by using of the concept of connected virtual and physical spaces. Engineering object (EO) model entities and their relationships (R) are represented in the well-proven product model space. Direct and indirect affecting human influences are organized in a human influence space. Humans build information content space that defines entities for product model space and controls organized simulations for virtual prototyping activities. Other spaces serve connections with the physical environment.

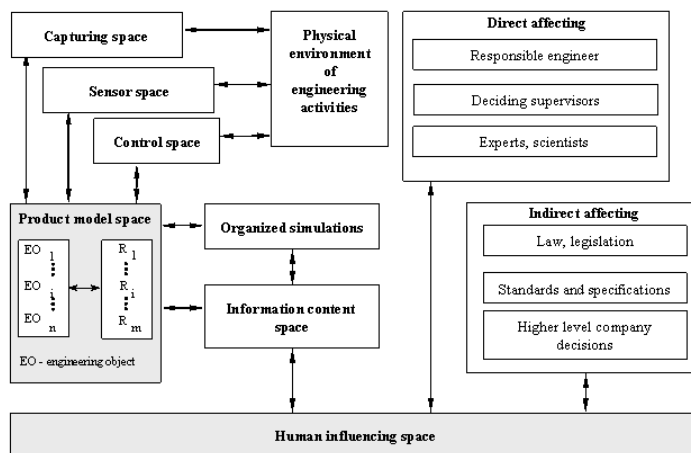


Figure 1

Enhanced human influence towards more intelligence in engineering systems

Key element of improving product modeling towards human controlled intelligence is definition and application of knowledge. Change for content based product modeling also means change for indirect knowledge definition. Figure 2 shows a comparison of direct and indirect knowledge definitions. In case of direct definition (dotted arrows), knowledge entities (Ke) are mapped directly to engineering object entities (EO). Indirect definition means definition and application of knowledge through content based processes.

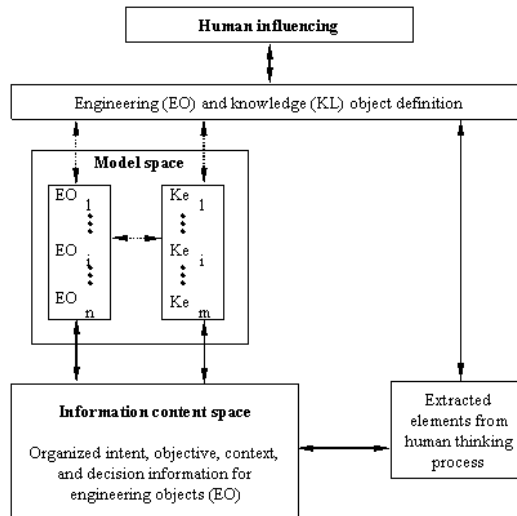


Figure 2

Change for indirect knowledge definition

### 3 Communication within Group of Engineers at Product Modeling

Automation of decisions on engineering objects requires consideration of all humans who has direct or indirect influence on the decided objects. Human influencing is result of single human thinking and its interdependencies (Figure 3). Definition of an engineering object considers information about definition by engineer who is responsible for the relevant task and about decisions from higher level of hierarchy. When two influences yield different results, any result must be recorded for possible later revision of the relevant decision. Actual information is synthesized for contextual definition of engineering objects. Model is constrained according to the actual decision. In accordance with the above mentioned recording policy, besides accepted and executed, rejected and argued states of decision are applied.

Information about actual definition by engineers who are responsible for a relevant task, together with actual interdependencies consists of elements of thinking process and interim decision points (Figure 4). Elements of thinking process represent the way to decision while interim decision points represent content of decisions for the definition of content in product model. Example sequences can be followed in Figure 4 in order to understand the above explained concept.

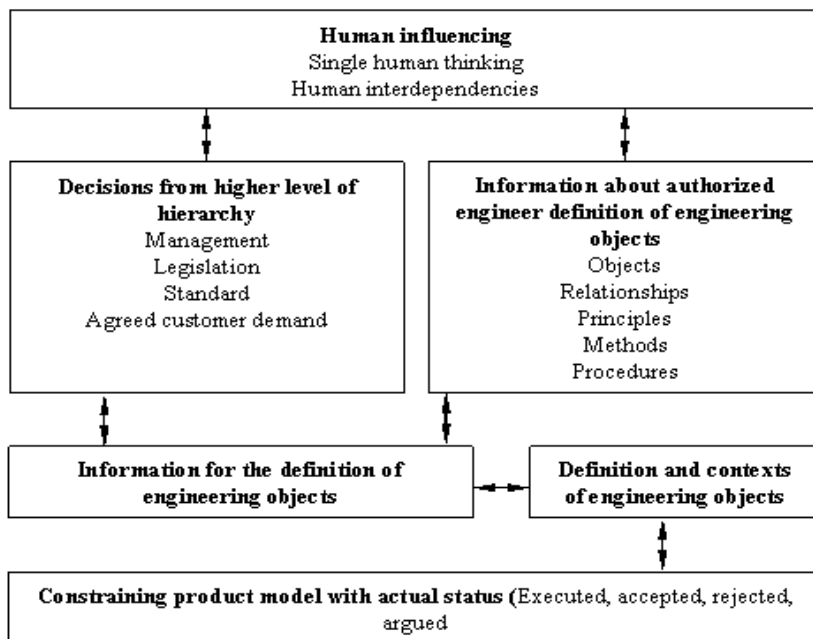


Figure 3

Essential processing of human influence

Current product models can not represent the decision maker at the application of the product model because the original decision can not be reconstructed, the original intent and the influencing intent carriers are unknown, and consequences of modification of existing engineering object definition can not be assessed. In order to achieve a possible solution for the above recognized problems with the currently prevailing product modeling, product model has been extended by the content that covers the *Modes does not include* items in Figure 5. The improved communication between the human who places information in the product model and the human who applies it is shown in Figure 6. Human applies knowledge at the definition of the so called intent. Really, human composes product related and personal knowledge in the product model in the form of intent. Following this, engineering objectives, contextual connections, and decisions are defined as content for the actual engineering object definition task. When retrieves product object model entities, human who applies the model, utilize content at

modification, improving, and development of engineering object complexes according to personal task and authorization.

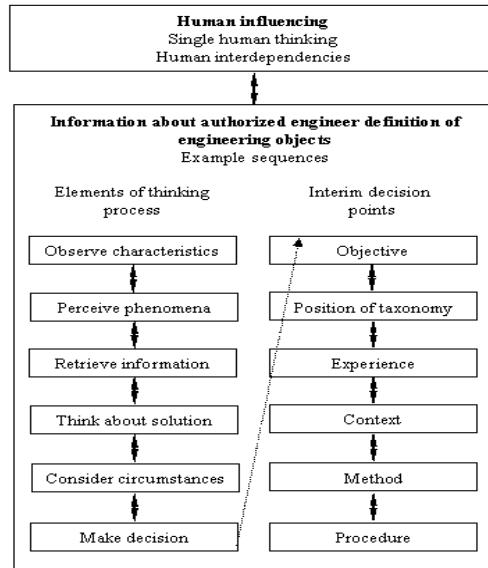


Figure 4

Extracting information content at object definition

## 4 Content-based Product Definition

Concept and method for information content starts from questions that must be answered by responsible and authorized humans at definition of engineering objects in the context of other engineering objects. Engineering objects should match with engineering objectives. These objectives come from human intent definitions. An engineering object is defined in the knowledge of information about engineering objects that are in relationship with it. For this purpose, contextual and non-contextual dependencies are to be modeled. Utmost purpose of information content is to establish a support of decision making engineering activities. Content is necessary to know about decisions as the basis of control of engineering object information in the product model space. A decision changes given engineering objects. Consequences of these changes are change of additional engineering objects that are in dependence connection with the originally changed engineering objects.

The process of content based product modeling is outlined in Figure 7 where product model activities and the relevant records in the product model are

summarized. At current object definition, human controls the modeling process by object parameter values or by relationships between actual and other parameters. In the proposed method, human defines intent for the attempted change of an existing product model. Intent entity in the product model includes information about intent holder person, strength and other characteristics of the intent, and elements and interim decisions as extracted from relevant human thinking process. Intent is applied at generation of engineering objectives as behaviors for given situations and circumstances [4].

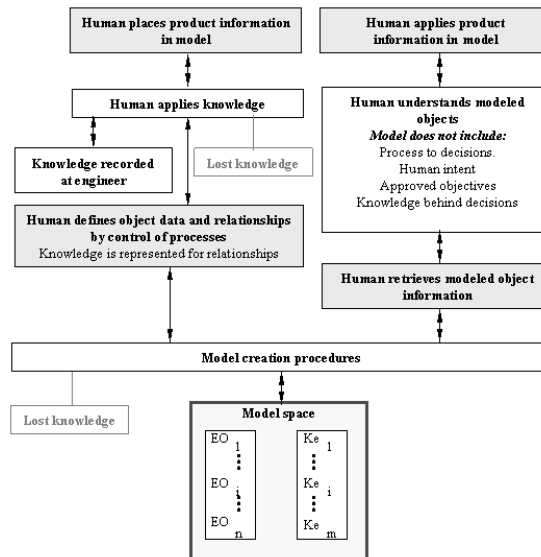


Figure 5

Communication in current product modeling

Any modification in the product model must be relied upon well-defined and approved engineering objectives. The next step is definition of contextual connections because this is the only way of any modification of the product model. Figure 7 illustrates the wide variety of conventional and advanced tools for this purpose. Following this, the main task is creation of decision in course of checking contextual chains for consequences of the decided change. Concept of change affect zone has been introduced in order to decrease the solution space. Change is defined as adaptive action for the control of engineering objects. For a finalized change, executable status of the relevant adaptive action is needed.

## 5 Future Work and Implementation

Research work in the next future in the reported research requires elaboration of modeling processes and model entities for representation of human intent and engineering objective. At the same time, the contextual content chain from human intent to executable adaptive action should be analyzed and implemented. This additional research is needed for starting research in open surface extension of currently prevailing modeling with communication and modeling with content. Virtual space as implementation environment is under construction at the Laboratory of Intelligent Engineering Systems within the organization of the Institute of Intelligent Engineering Systems, John von Neumann faculty of Informatics, Óbuda University.

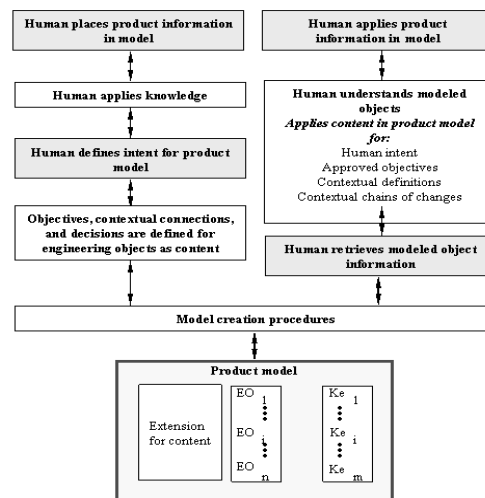


Figure 6

Communication in the proposed product modeling

## Conclusions

In this paper, the authors reported a research with the purpose of enhanced knowledge communication and representation in product modeling systems. The starting point is the current virtual technology and methodology as realized in modeling systems for lifecycle of products. Modeling capabilities of these systems were analyzed in order to recognize possibilities and necessities for their improvement towards more intelligent solutions. The main method is human definition of intent, then application of intent at the definition of engineering objectives and contextual connections for engineering objects. By using the above content, decisions are coordinated taking contextual chains of engineering objects into consideration. The result is adaptive action on relevant parameters of relevant engineering objectives. Change is realized when adaptive action gains executable status.



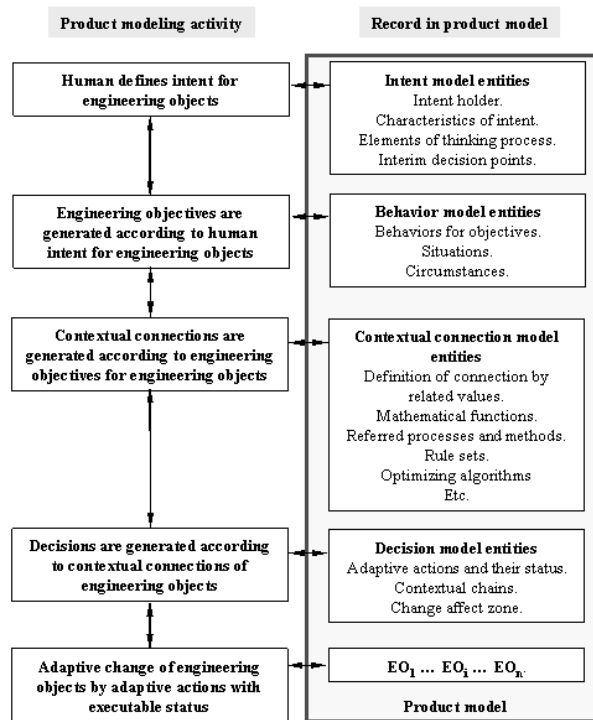


Figure 7

Essential process of content based product modeling

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