Request Driven Generation of RFLP Elements at Product Definition

László Horváth(✉) and Imre J. Rudas

Institute of Applied Mathematics, John Von Neumann Faculty of Informatics, Óbuda University, Budapest, Hungary
horvath.laszlo@nik.uni-obuda.hu, rudas@uni-obuda.hu

Abstract. Recent achievements in product modeling emphasize self adaptive instancing of generic models, active intelligent property (IP) representations, and multidisciplinary product concept definitions. Although current leading product lifecycle management models (PLM) are in possession of these advanced capabilities, new complexity related problems arise at definition of active knowledge and higher level abstraction model entities. As contribution to solution for the above problems, this paper introduces new request driven behavior centered method for the generation of requirements, functional, logical, and physical (RFLP) structure elements and active knowledge features in PLM model. The requirements, functional, and logical elements provide high level abstraction for representation of multidisciplinary product concept design while knowledge features assist generation of product features on the physical level. The proposed method is aimed to be suitable for intelligent application purposed extension of PLM modeling systems.

1 Introduction

Representation of product information in order to achieve better engineering activities and support design, analysis, and manufacturing automation started to develop at engineering areas where conventional drawing and documentation failed. Examples for these areas were representation of three dimensional surfaces (CAD), finite element analysis (CAE) and computer aided programming of manufacturing equipment (CAM). These isolated solutions were gradually integrated into product model where new aim was to support all engineering activities during the lifecycle of product from the first idea to legal recycling. Development of model for product lifecycle management (PLM) system included more or less integration of models from various engineering areas. However, real integration of mechanical, electrical, electronic, software and hardware representations in a single model was possible only on the conceptual design of multidisciplinary product. In order to realize this, well proven model structure was introduced from systems engineering (SE). This is the requirements, functional, logical, and physical (RFLP) structure.

The above changes were associated with new solutions for handling changes in the growing model structures during the development of products in order to fulfill demands for well engineered products and shortened innovation cycle. These demands enforced advanced generic, feature driven, knowledge controlled, contextual, and self

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adaptive characteristics of PLM model. The Laboratory of Intelligent Engineering Systems (LIES) at the Óbuda University joined to these efforts in research for model representations which give better handling of high level abstraction and human request driven self instantiation in PLM models. This chapter introduces one of recent results at the LIES. This result is a new model structure to assist human request originated content driven generation of elements in RFLP structured PLM models.

2 Knowledge Driven Self Adaptive Product Model

Engineering activities for lifecycle of increasingly complex products have been concentrated in highly integrated product lifecycle management (PLM) modeling systems [6]. This integrated modeling methodology was grounded by the Integrated Product Information Model (IPIM) which became international standard. In order to achieve capability of PLM model for self modification in case of changed situation and new event, active intellectual property (IP) driven generic product model constitutes key area of PLM research. As result, recent PLM models are capable of self modification through chains of contextually connected product features [1]. Model modifies itself for changed situation and new events through chains of contextually connected feature parameters. PLM model demands feature definition for lifecycle of product [9].

Recent developments of product model system completed the pure physical level product model with request, functional, and logical representations in RFLP structure. In this multidisciplinary model, R, F, and L levels provide representation of integrated product concept for mechanical, electrical, electronic and other area specific product units in a single model [2]. F and L levels are capable of behavior representation providing virtually executable PLM model. The way is open for intensive application of active intelligent content in product model [1].

The request driven behavior centered generation of RFLP structure elements which is the main contribution in this chapter assists development of product lifecycle management (PLM) model in a modeling environment which is outlined in Fig. 1. First of all, the most important change is that modeling is multidisciplinary in order to achieve really integrated representation of multidisciplinary product. The previous efforts for interdisciplinary group work engineers resulted connected or integrated individual results while multidisciplinary group work provides results which are built on each other. Organic integration of mechanical, electrical, electronic, hardware and software units in a single common model is done only on the conception level of product design.

In the new scenario of engineering, human contributes to product development by RFLP structure based product definition. The request driven behavior centered generation of RFLP structure elements applies content which is suitable to replace direct human decisions on these elements. Following this, the model definition is continued on two branches. Separation of physical level development gives the possibility for direct physical level product definition. At the same, time, product concept definition on the other branch makes integration of R, F, and L level abstraction entity generation with the physical level definition possible. On the physical branch, physical (P) level definitions initiate active knowledge feature generation and product feature generation. Generic model is developed which is capable of self adaptive instancing [8].

The request driven behavior centered generation of RFLP structure elements was motivated by the problem with R, F, and L structure element dialogues. Capturing complex contextual knowledge in the course of these dialogues is a new challenge for engineers. The proposed method is aimed to develop representations for collected active knowledge content in product model. This content drives RFLP element generation. At full application of the proposed method, multidisciplinary product concept is defined prior to physically existing parts.

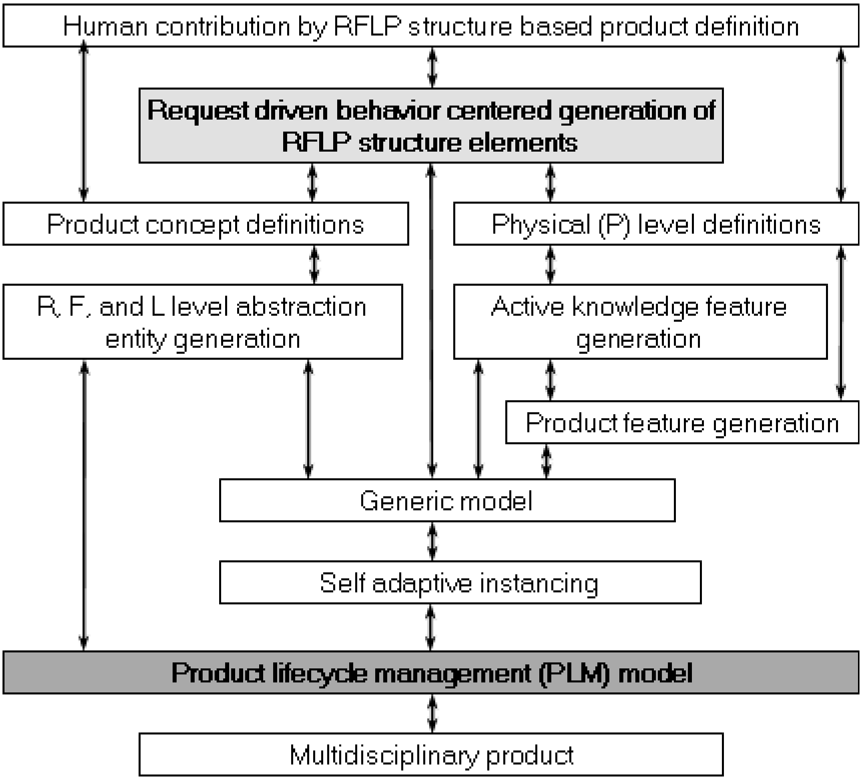

Fig. 1. Modeling environment of the proposed product definition

Because the proposed modeling is dedicated for RFLP structure element generation, it is planned to integrate in a PLM system with RFLP structure development capabilities. At the same time, these capabilities can be utilized at the request driven behavior centered model. In order to realize this advantage, configuration and open system capabilities should be applied. This implementation is not a subject of this chapter.

The main RFLP structure and the proposed driving content for each level are shown in Fig. 2. RE, FE, LE, and PE elements are placed in level structures for requirements the product has to fulfill (R), function (F) to fulfill requirements, logical structure of product (L), and physical (P) representations of real world product, respectively. Because level of RFLP structure is a structure of elements, the proposed model for driving content consists of levels and element structures on levels. Content for the R, F, L, and P level elements is available in relevant elements on levels of initiated requests, product functionality, context structure, and action structure, respectively.

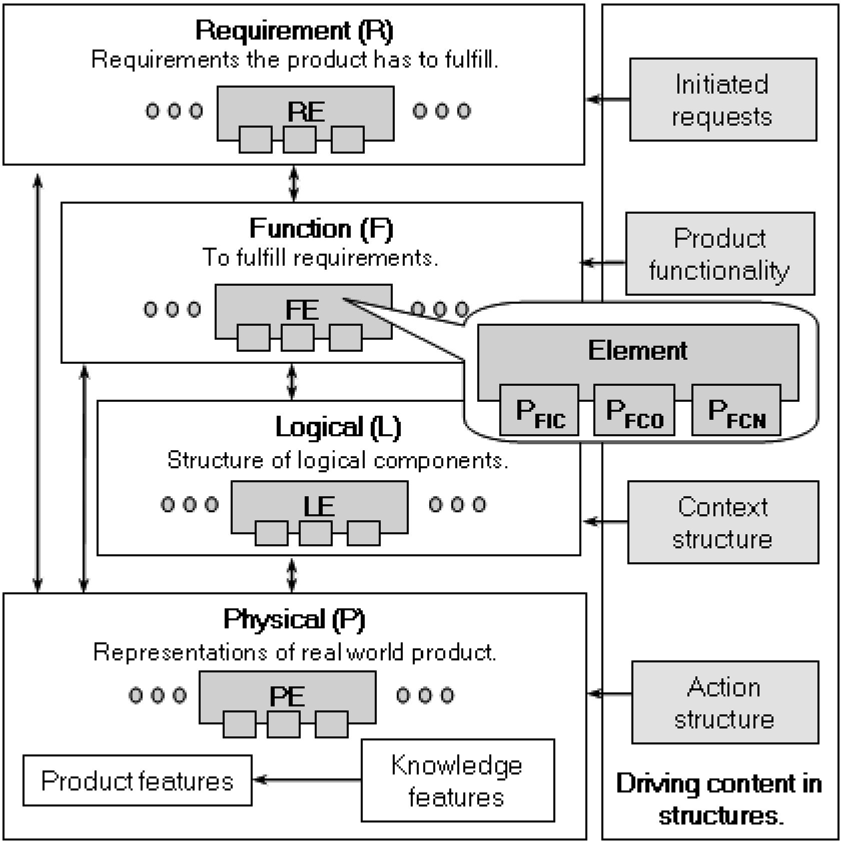

Fig. 2. RFLP structure elements and the proposed driving content

The RFLP and the proposed content structure elements are connected by ports (Fig. 2) for inter-element communication (P_{FIC}, control of element (P_{FCO}, and for exchange of content information (P_{FCN}). Driving content consists of coordinated human request representations and their processing into lower level entities such as behaviors, contextual connections, and physical level object parameters. Formerly applied knowledge, experience, and expertise entities are represented in content elements and applied as consistent intellectual property (IP) in product model. In order to achieve this, the abstraction method in the proposed modeling is based on the five level abstractions in [4].

3 Request Driven Element and Feature Definition

Structure of content for the request driven behavior centered generation of RFLP structure elements is summarized in Fig. 3. Encircled letter *C* means driving connection in the direction of arrow. Engineer submit request in the form of content. Request may be initiated or already decided. Authorization is controlled by relevant PLM procedures using allowed context for each interacting human. Initiated requests are recorded and placed in structured request (SR) as organized initiatives. SR organizes requests from all engineers who are in appropriate context. Decided requests are included in actual product definition. Content is mapped to organized initiatives. Structured request (SR) includes initiatives for product functions, specifications, objects, processes, and entity generation methods. Definition and decision [7] activities enhance and complete this structure during the lifecycle of product.

Because behavior representations in F and L level elements of RFLP structure enhance product model into virtually executable one, content for behavior has key importance on the way of development of the proposed modeling. Requests are converted into product behavior (PB) definition considering their structural connections in SR structure. Product behavior (PB) content definition is controlled by product functionality and product characteristics. Behavior related content is placed in structured behaviors. In PB, structured behaviors can cover all of the product functionality and characteristics using a previously published generalized definition of behavior [5].

In this stage of content definition, product structure is available in the form of awaited and decided product behavior definitions. Behavior controls generation action (GA). GA is a structure which backed up by content in the form of constructor and active knowledge product features for the P level of RFLP structure. GA structure also can be configured for direct drive of product and knowledge features in conventional P level product models under the coordination of CD structure.

P level object contexts are organized logically in context definition (CD) structure. This can be defined prior to physical object definition and includes content for logical structure of product. This content drives L level element generation in the RFLP structure. Direct context drives logical connection for product objects while indirect contents drives logical connections of driving knowledge objects and driven product objects in the product model. In the indirect case, logical connections are established between object which change knowledge objects parameter values and results firing of knowledge objects.

As it can be followed in Fig. 3, the proposed modeling is composed by contextual chain of SR, PB, GA, and CD structures. Elements in these structures have driving connections to relevant contextual RFLP structure elements as it is summarized in Fig. 4. Driving contexts in Fig. 4 were mentioned above. Content background and driven RFLP structure level driving connections include SR-R for requests, SR-F for functions, PB-F and PB-L for behaviors, GA-P for physical object generation, and

CD-L for connections in logical model of product. In the course of definition of content structure and its driving connections, arbitrary connection of elements within and between content driving content background and product RFLP structure can be established in accordance with the context of engineer who defines the connection.

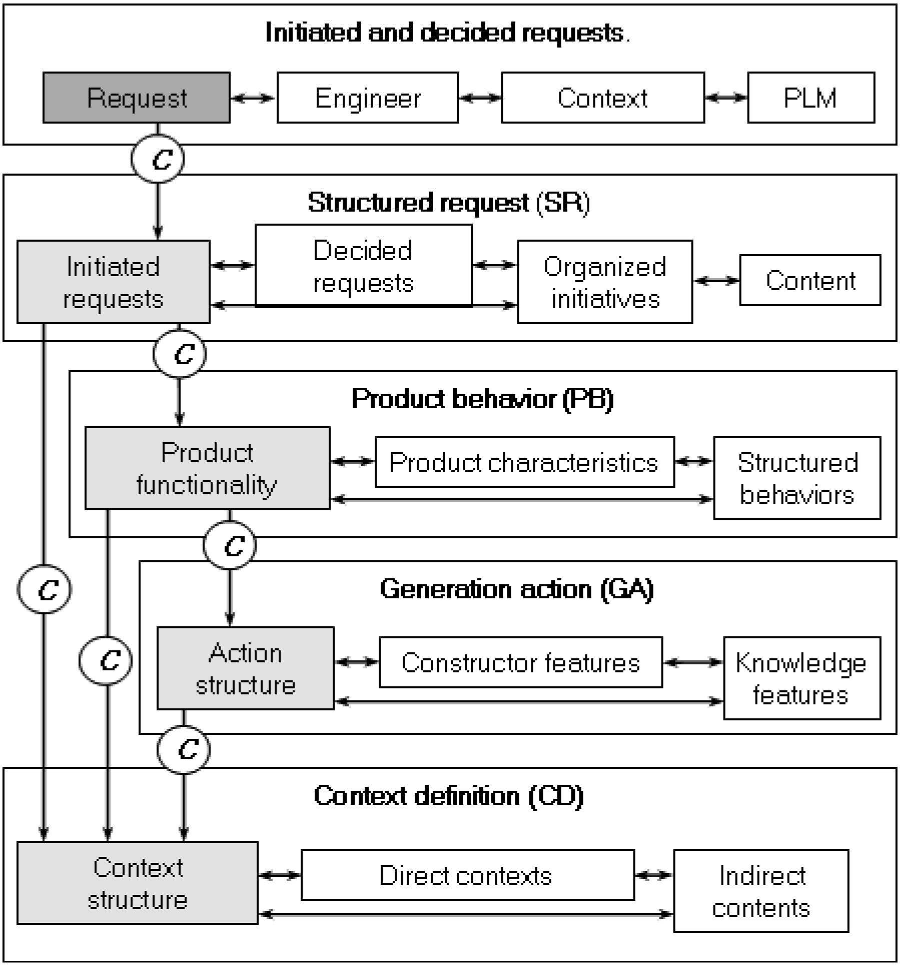

Fig. 3. Content structure for the proposed modeling

Driving connections and the connected content between levels of the content background (Fig. 3) implies complex content representation structure on each level. For the inside structure of levels, content type based substructures were proposed (Fig. 4). Substructure is a structure of elements on a level. RFLP structure management of known PLM solutions allows for establish structure within level of RFLP structure. This practice is planned to apply also on content levels. Because content elements and connections may be very complex, generic modeling must be applied for the greatest extent possible. On the level of structured request (SR), substructures are proposed for request specification (RS), requested product function (RF), requested objects (RO), requested definition method (RM), and requested definition process (RP). RS specifies human defined request which includes specified objects and their specified parameters and drives relevant RF, RM, and RP element definition. In other words, specification initiates content for product function, as well as product entity definition method and process. Sometimes sets or patterns of product objects are mapped to function. Along the contextual chain in Fig. 4, product object may be specified along with its definition method or process. Finally, definition process may be driven by method. The SR structure is extended and improved during the lifecycle of product. Driving RFLP structure elements by SR elements can be restricted to critical engineering activities.

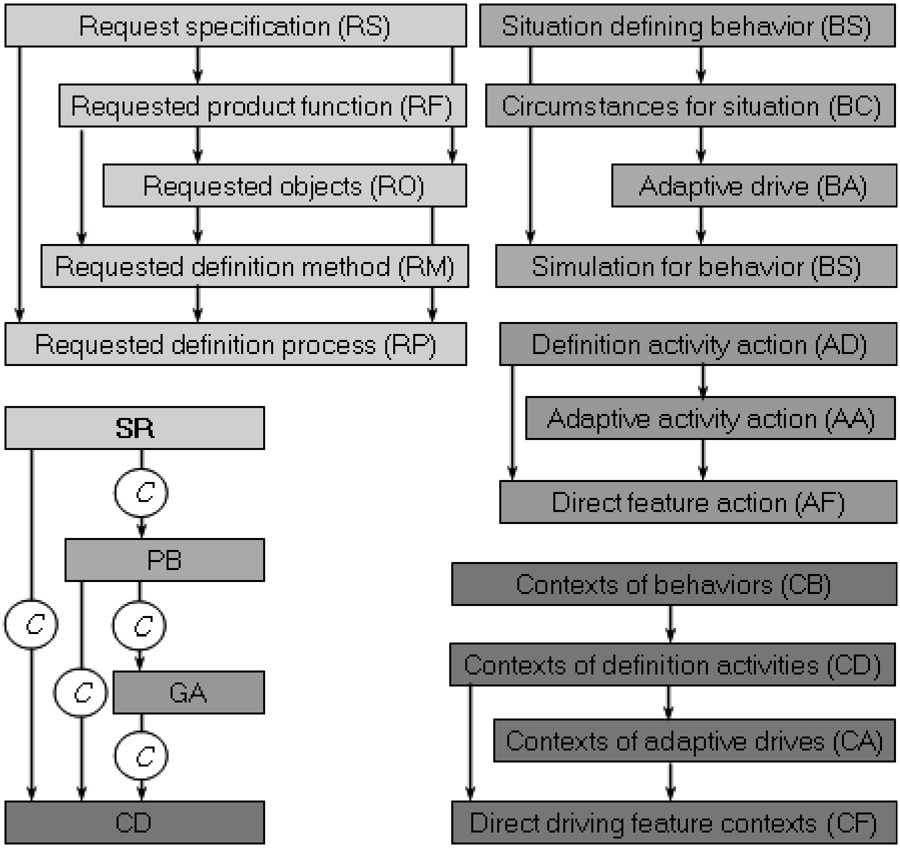

Fig. 4. Substructures on levels of content structure

On the level of product behavior (PB), substructures are proposed for situation which includes content for defining behavior (BS), circumstances (BC) in the form of set of parameter definitions in the background of situation, adaptive drive (BA) which includes content for the drive of product objects, and simulation (BS) which is for analyses in order to assure defined behavior. Elements in this level are defined in the context of structured request (SR) substructure elements. While contextual connections are established between elements, content transfer is done by object parameter values and relationships.

On the level of generation action (GA) definition activity action (AD), adaptive activity action (AA) substructures organize product feature, and knowledge feature generation content. Direct feature action (AF) substructure is record of direct human feature definitions. Context definition (CD) level includes substructures for the four main types of logically connected model entities as it can be seen on Fig. 4.

4 Conclusions

In this chapter, four leveled driving content background is proposed in order to connect engineer requests for product definition with generation of RFLP structure elements and product and knowledge features by using of request driven and behavior centered method and model representation. The proposed modeling is a contribution to recent developments in product model system in order to complete the conventional pure physical level product model with request, functional, and logical representations of multidisciplinary products in (RFLP) structure. It was devoted to improve integration in existing RFLP structure enabled PLM model structure by using of substructure elements and their ports of advanced host PLM systems.

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