# A CONTENT MANAGEMENT FRAMEWORK FOR PRODUCT DEVELOPMENT

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**Keywords:** Content management, product data model, process model, content circle, knowledge management, CM methods and tools

**Abstract**: *The framework described in this paper represents a model to structure all the topics relevant in context of content management. On basis of specific definitions of the terms content as well as content management in a product development context the elements within this framework and their interrelations are described. These elements are a product and a product development process representation which are linked by the content itself, methods and devices for content management, and systems, instruments, and tools for supporting content management activities. At the end of this paper, finally, the adaptation of two known knowledge management methods to the demands of content management is shown.*

## 1. INITIAL SITUATION

To create products of very high complexity, such as ships, aeroplanes, or spacecrafts, without loss of time, money and other resources there is a need of making available a wide range of knowledge, information, data and documents in the right time at the right place. This means, that the product related *content* necessary for making decisions within a product development process must have a format suitable for processing this content, must include the needed information and knowledge, and must be linked exactly to those product development process steps where it is needed.

The paper at hand describes a framework which on the one hand connects a product view representing product related content with a process view describing product development process chains. On the other hand this framework includes specific methods and devises as well as systems, instruments and tools for managing the content. The content management methods and devices which are placed within this framework can be taken from already known disciplines, like business process management, knowledge and information management, as well as knowledge based engineering. They have to be adapted to the requirements of content management how it is defined in this paper. The use of specific systems, instruments and tools helps in establishing an efficient and effective management of product related content.

## 2. CONTENT

First of all, the term of content in context of product development how it is understood in this paper is explained. With reference to the already known understanding of content management (see chapter 3) content, in principle, is defined as any information which is kept in information systems. Nowadays, content is administrated in data bases. It is made available in a well structured, poor structured and unstructured format. Well structured content consists of data which are made available in a standardised layout through data based systems (e.g. formatted sets of data). Poor structured content is information and documents which consist of layout and meta data, but which are not standardised (e.g. word processing data). Unstructured content consists of any information objects which do not realise a separation of subject matters, layout and meta data and of which subject matters can not be deduced directly (e.g. images, GIFS, videos, speech, etc.). Content always is a combination of subject matters and meta data. These meta data are not necessarily visible for the user. They mainly serve as an administration and control means of the subject matters. A very important component of content management systems, thus, is the separation of layout and structure information out of the subject matters.

The point of view to a definition of content which is relevant in a product development context is similar to the characterisation of this term described above: According to this characterisation, content generally

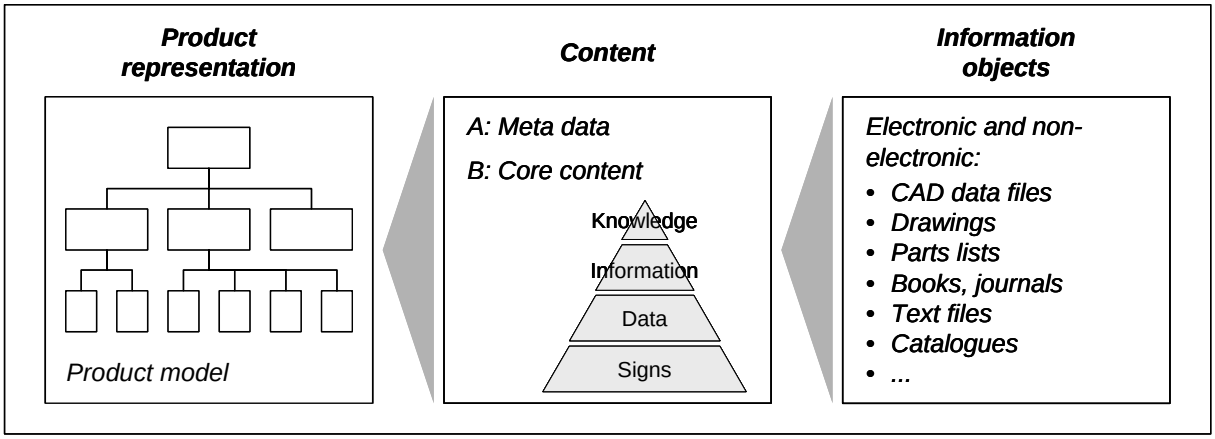


Fig.1. *Elements of content*

can be data, information, and knowledge which are represented by any information objects such as, e.g. texts, technical drawings, cad data files, lists, etc. These information objects could be available in an electronic as well as in a non-electronic format.

Before this background, a representation of content in product development consists of three elements (see figure 1): Firstly, there is a strong need for a product representation to be able to sort the content into the product structure and exactly to identify the product related content which is needed to proceed the product development process or which serves as a basis for a decision within this process. Thus, the first element of a content representation is a product model, which exactly structures the respective product, its assemblies, component parts, etc. For different kinds of products there must be specific reference models representing these specific kinds of products. Secondly, the content itself has to be determined. For this determination, in the research field of information management a so called *knowledge pyramid* has been developed which shows different stages of content starting with signs, throughout data and information, up to knowledge [3]. So, this pyramid completely represents all kinds of content which is relevant in product development. Additionally, the content includes meta data to support the identification of specific content respectively of the information objects needed for a decision within the product development process or for continuing this process. Meta data are defined as data or information that describe the structure and the format of the content as well as the information objects and its position within a product model. Thirdly, there must be a representation of the content itself which can be realised throughout so called *information objects*. These objects on the one hand can be made available through electronic formats. They can be stored and administrated in data bases. On the other hand, they simply can be made available through books, magazines, paper drawings, or other paper documents which are non-electronic formatted objects. The third level of content is necessary to communicate content needed to the users of this content.

## 3. CONTENT MANAGEMENT

According to the given explanation of content, in this chapter, a definition of content management in context of product development is formulated. Actually, there are three main views from which the content management term is occupied:

Firstly, in a closer, “classic” meaning of content management this term is used when digital information is made available for different purposes, especially for commercial marketing or distribution purposes. In this context the content, e.g. includes digital books, videos, or music which must be administrated, charged, protected, and distributed for consumers. The owners of such content aim at exploiting this content commercially regarding to the customers’ demands and wishes. Within the context explained above content management consists of all activities, processes and devices supporting the life cycle of digital information in terms of manuals and documents.

A special view on content management derived from the “classical” meaning explained above are topics called Digital Asset Management (DAM), Media Asset Management (MAM), or Rich Media Management (RMM). These approaches are characterised by the storage and administration of any digital content, especially media data such as graphics, videos, music data, and texts.

The second direction content management is viewed at is named *web content management*. This direction of content management includes the administration of content on websites and internet based portals. Web content management focuses mainly on the versioning of websites, the integration of protected intranet areas, e-commerce, dynamic feeding of websites out of data bases and efficient tools for supporting the edition process of creating web content and publications. The appropriate tools are especially directed to formats which are used for building up websites such as HTML, XML, or GIF. Web content management, today, is a basic technology for the creation of web portals.

Finally, the third view on the content management term gives a rather general definition because it is directed from a of business processes context. Thus, the term *enterprise content management* is introduced. Enterprise content management is defined as "the technologies and methods used to capture, manage, store, preserve, and deliver content and documents related to organisational processes" [1]. The administration and processing component also includes conventional technologies which are document management, collaboration, web content management, work flow management, and records management. It integrates host and client-/server-technologies with all kinds of internet technologies. Enterprise content management aims at avoiding redundancies of data and documents, it ensures a consistent data access, and it supports the retrieval of any information independent of its sources and its use. Enterprise content management integrates solutions which use internet technologies but which at the same time aim at making available any information within a company. This means, that any structured and unstructured information within a company should be made accessible for the actors who need the information as a basis for decisions or for continuing their tasks within a business process. Thus, enterprise content management provides a multi level infrastructure necessary for arbitrary applications.

In contrast to the views on content management described in the passages before, the author aims at establishing a broader sight on this topic, especially in the context of product development: From his point of view content management includes all the methods, instruments and tools for creating, capturing, administrating, storing, delivering, and preserving not only digital content but also content which is available in a non-electronic format. Thus, these methods, instruments and tools include both technological as well as methodological solutions. Further more, throughout content management there is built up a link between the content used for describing a product with all its facets and the process steps necessary to develop this product along the phases product planning, resolving of development tasks, product conception, product design, and product elaboration [2]. Thus, there is a need for models which, firstly, support the identification and classification of product describing content and its mapping to the product structure – a product data model – and which, secondly, allow the description and structuring of business processes – a process model. These two models have to be linked throughout the content to be managed to the product development organisation.

Management in the context described above means the acquisition, storing, and distribution of product related content as well as the control of the product development process. With reference to the aspects presented, the author gives a very widespread definition of content management in context of product development:

*Content management includes the methods, instruments and tools for identifying, making available, processing, structuring and purposeful usage of product related content as a basis for decisions in product development and for continuing the product development process. Consequently, these methods, instruments and tools serve as devices to link product related content with the affiliated product development process, respectively, with specific product development process steps.*

To support the second section of the given definition the author developed a model – the so called *content circle* – which describes the core interrelations between a product content view and a product development process view. This model classifies the content needed for specific product development tasks to the single process steps of the product development process where these tasks are carried out (see chapter 4).

## 4. CONTENT CIRCLE

One core element of the content management framework is the illustrated model for linking the product structure view with the product development process view, the *content circle* mentioned in the chapter before. This circle consists of three main items which are linked to a circle by the content itself or by its attributes. These three items are a product representation in terms of a product data model respectively a product model, a process representation which normally is illustrated via a process model, and a method which supports the identification of the subject matters as well as the characteristics of the content for every single product development process step.

### 4.1. Product and Process Representation

The product representation serves as a means to structure the product related content which is created during a product development process and which describes a product in all its facets, such as its geometry, the material it is made of, its function, or the component parts to be mounted. This representation results in a product model which is built up on the basis of a product data model. A product data model is defined as "a conceptual model of the product in which information on the product and the connections between various information elements and objects are analyzed at a general, generic level" [4]. The product related content can be made available throughout any information objects (see figure 1). As it never would be possible to create a universal product data model valid for all kinds of products it is necessary to build up product data reference models, e.g. for one-of -a-kind products like ships or industrial facilities, for variant products which are produced in small series like aircrafts, for serial products like automobiles, and for mass products like electric drives or pumps. Thus, there is a need for various product data reference models with reference to specific engineering and product struc-

tures. To support a processing of such product data reference models via information systems, this model ideally would be described throughout an XML scheme which represents all the correlations between the product related data.

The process representation within the content circle alleges that structure along which the product related content on the one hand is created and on the other hand is needed. It illustrates the process for developing a specific product via a process model. This process model shows the process chain of the product development process with its single phases down to the single process steps for the development of a product. There are different possibilities for building up a process model of the product development process, such as the illustration and description of the activities to be carried out along a product development process chain by an activity diagram or by an incident-driven process chain which differentiates between the activities and the incidents themselves. Within the incident-driven process chain method the incidents serve as an initiator of the following activities. Further mode, via this method the content input and the content output as well as the actors of every activity are shown. To give a detailed illustration of the respective product development process via a suitable model the incident-driven process chain is identified as the favoured method. Similar to the product representation, also for the process representation with respect to specific types of product development processes process reference models could be developed.

## 4.2. Formal Interaction Analysis

To be able to formulate clear requirements to the content needed in the single process steps concerning the subject matters as well as the characteristics of this content a method is needed which supports an analysis of the interfaces between the process steps respectively the information and communication activities between the actors of these process steps. A suitable method for this analysis which has been developed at the Bremen Institute of Industrial Technology and Applied Work Science in the late 90ies is the Formal Interaction Analysis (FIA) [5].

The FIA methodology is based on a meta model which has an *interaction* – a small scale scenario of information exchange between actors – in its centre. A trigger for an interaction is product development tasks that are carried out by *actors*. Each task has an information need which is not only determined by its subject matters but also by the characteristics of the needed content for making it useful [6]. The transformation of the model described leads to a methodology for designing an information and communication structure. The steps of the FIA methodology (cp. [5]) relevant for processing the content circle are the *capturing of the information need* and the *specification of the information characteristics* as well as the *modelling of the interaction scenario*. In the first step mentioned the information need for carrying out the tasks is identified. It is defined in terms of information objects. In the second step every information need is examined with respect to the characteristics and the specification the information must have. Throughout modelling the interaction scenarios the information sources, communication means, and communication patterns which could be appropriate for fulfilling the information needs are defined. The needed information characteristics are mapped against the characteristics of the communication means. On basis of these analysing and conceptual steps different solutions of suitable information and communication structures have been developed which help to make available the needed content as well as its respective subject matters and its characteristics [6].

The use of the FIA for analysing the interactions between the actors of the product development process steps supports the formulation of the requirements concerning the needed content and its characteristics, the necessary information objects the content is transferred with, and the used communication means. According to these demands the needed content is taken out of the product model which step by step is built up through the appropriate product development activities. Thus, as a kind of answer to these demands the needed content must be made available exactly as demanded. Therefore, specific models, instruments and tools have to be found which are able to transfer these demands to targeted requests of the needed content at the product representation and to make the content available for a specific process step with exactly that characteristics it is demanded.

## 4.3. Processing the Content Circle

At the very beginning of the development of a product a suitable product data reference model has to be identified, adapted to the characteristics of the specific product development project, and fed with the starting basic content taken from an order or a requirements specification as well as with all the other available content useful for the respective product development project. Further more, the product development process chain has to be known and made transparent. Before this background, an identification of the content and its specific characteristics needed for continuing a product development project starting with the first process steps will be realised. So, the content circle is initiated and will be continued as follows:

In the first step of the circle the content which is needed for a decision or for processing the product development process as well as the respective subject matters and characteristics is identified. For this identification the Formal Interaction Analysis is applied to the interaction preceding the process step which has to be carried out next in the process chain. When the needed content is identified it has to be extracted either out of an information system, e.g. a product data management system, or from the actors in the product development process chain who are handling this content in a non-electronic format.

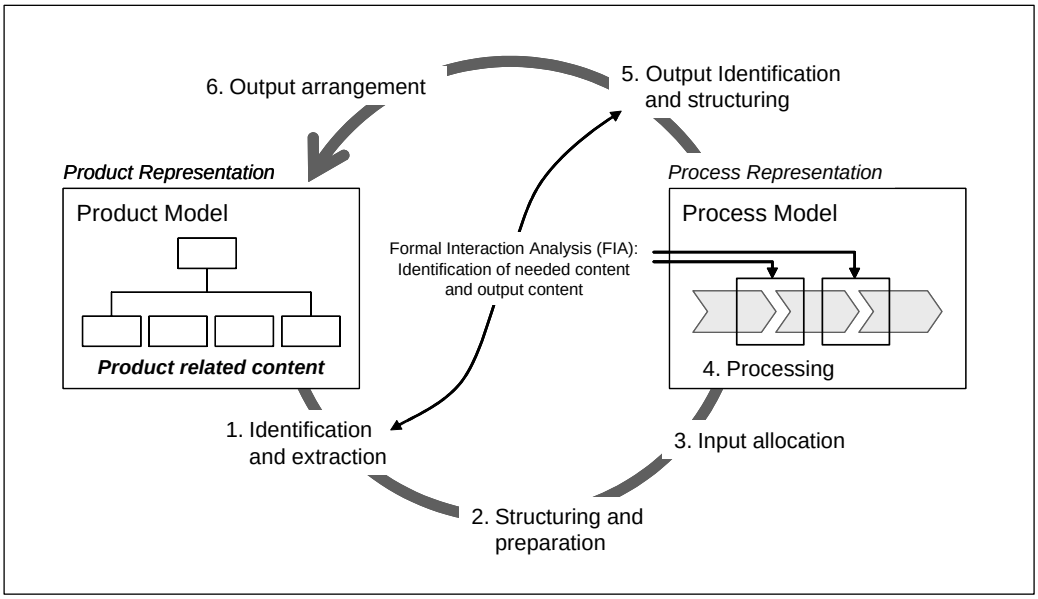


Fig.2. *Content circle*

The identified and available content, in the second step of the content circle, is structured and prepared, so that it exactly shows the characteristics necessary for an effective and efficient processing the process step following the analysed interaction. Besides the information objects by which the content is transferred to this process step, also the format of the content, the used communication means, or the communication patterns could necessarily be changed, so that they meet the requirements of the analysed interaction. The preparation of the extracted content can include its processing, e.g. through algorithms or through the use of technical tables or diagrams, so that new content is created or the characteristics of the content are changed. The results of such a processing serves as input which is identified as the demanded content and its related characteristics by the analysis of the particular interaction.

In the third step of the content circle the allocation of the prepared content to the appropriate process steps is realised. The allocation can be supported through content characteristics meeting the demands of the interaction, especially through suitable communication means and information objects.

The fourth step of the content circle is indicated by processing of the content itself.

In the fifth step, the new content which is created by processing the input content has to be identified and structured. For the identification of the output content and, especially, of the subject matters and the characteristics of this content the FIA method can also be used. Therefore, the interaction following the viewed process step has to be analysed focussing on the aspect of determining the characteristics of the output content. When the analysis has been finished the new content can be appointed, the information objects representing this content as well as some other important characteristics are identified, and the content can be structured according to these characteristics.

In the sixth step which closes the content circle the new content created throughout the viewed product development process step is arranged into the product model valid for the product which actually is developed. With this arrangement, the core requirement for quick finding specific content created throughout a product development process is fulfilled. The new created content is implemented into a product model structure which supports a quick and easy identification of exactly that content needed in specific product development process steps. The pre-condition for this identification is that the content already exists.

Throughout the processing of the content circle, the product development process proceeds step by step. Thus, more and more content is created and the product data model which has been one starting point of the development of a product changes to a product model which becomes more and more concrete. So, the model represented by the content circle supports the integration of the product view and the view on the relating processes for the development of this product.

## 5. CM FRAMEWORK

All the ideas, models, and instruments discussed in the paper at hand can be integrated to one framework which describes the research fields of content management in the context of product development (see figure 3): Firstly, there are the product view and the process view on the product development activities. These views which are represented by appropriate models are linked throughout the content itself. The integration of these views is illustrated via a

model – the content circle – which describes the erection of the product model realised by the arrangement of the created content when continuing the product development process. This process also can be represented through a process model. Especially, the creation and description of the two models or of reference models according to a specific engineering respective production system are important research fields within the content management framework. Further more, a more detailed description of the content circle, a research of the interrelation effects, and the development of methods, instruments, and tools for processing the content circle could be carried out within the framework.

Secondly, methods and devices for content management in a product development context have to be developed and described in detail. These methods and devices can be taken from already established disciplines and adapted to the demands of content management. Also completely new methods and devices can be developed. A third aspect relevant in the content management framework is systems, instruments and tools. These systems, instruments and tools are mainly technical solutions for content management which also can be taken from other disciplines and adapted to the content management demands.

The elements described before which are methods and devices on the one hand and systems, instruments, and tools on the other hand can be summarised under a content management roof. Thus, there are two core models within the content management framework. Both of these models comprise the content management itself. These models are the content circle on the one hand and a content management model consisting of three model elements – the content itself, methods and devices, and technologic means – on the other hand. This content management model aims at making available all kinds of approaches and solutions supporting the processing of the content circle.

Generally, the framework described allows a positioning of single solutions, methods, instruments, tools, or models which support the improvement of the availability of any content necessary for the development of a product. It gives a structure for the illustration of the correlations between all these elements which could be discussed in detail within the content management framework. Every single of the elements illustrated in figure 3 describes an own, wide-ranged research field. The content management framework aims at giving a structure under which these research fields will be discussed with reference to content management in context of product development. Thus, a new research field is created which helps to improve the efficiency and effectiveness of product development activities by developing generic as well as specific solutions for managing product related content needed for carrying out these activities.

## 6. METHODS AND INSTRUMENTS

To illustrate possible content management solutions within the described framework in this chapter chosen methods and instruments are taken up from the discipline of knowledge management. Furthermore, the demands of a content management context as well as the use of the transformed methods and instruments in this context are shortly described. The chosen methods and instruments are, at first, the *data warehouse* which stores all kind of product related data and, at second, the *knowledge roadmap* which supports a structured identification of knowledge sources and persons with specific competencies and knowledge concerning dedicated product development activities.

### 6.1. Methods' Description

A data warehouse described at first summarises all the codified know-how of an organisation which in

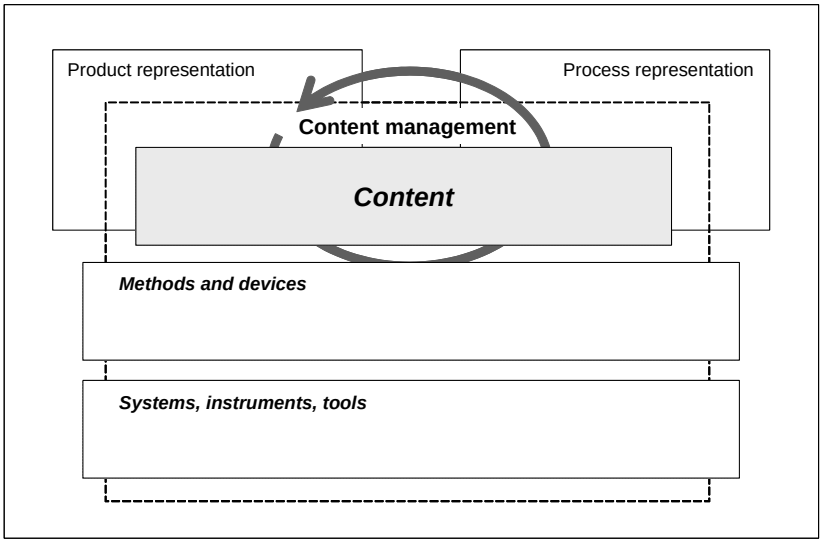


Fig.3. *Content management framework*

this way is collected and made available to the organisation. The data warehouse administrates, structures and stores data needed for analysis of long term time periods. Throughout using these data, e.g. new technical solutions could be worked out by combining the stored data, information, and knowledge. A data warehouse constitutes the pre-condition for an effective and efficient processing of well-structured information within an organisation. It is an obligatory basis to be able to carry out trend analysis, data mining, and other analysis tasks. In a knowledge management context this data and information stored in data warehouses which are expected to contribute to carrying out a task are extracted from the warehouse. They are enriched to knowledge which is of importance for the organisation through their combination with a specific task or problem. Suchlike prepared, these data and information become an important knowledge basis on which assured strategic decisions can be made.

The knowledge roadmap as the second example method is a structured documentation and visualisation of knowledge sources and knowledge-bearing persons. This roadmap is a kind of a plain structured data base which refers to the know-how and knowledge of single persons and which can be accessed and edited throughout the organisation intranet. Relevant knowledge fields and knowledge-bearing persons as well as the actual status of knowledge relevant for a decision are made transparent and available through graphical schedules consisting of a unique structure. Knowledge roadmaps can be configured dynamically by supporting extensions of subject matters as well as amendments. It is an important demand that the knowledge roadmaps are administrated regularly.

## 6.2. Methods' Adaptation

The main adaptations of the two methods described are the extension of these methods from a knowledge focus to a content focus. Thus, according to the given representation of content (see chapter 2) besides knowledge also signs, data, and information as well as the information objects representing the content have to be part of the methods. Before this background, both methods require a clear structure according to which the content will be stored and represented.

Thus, especially, in the data warehouse there is a need for suitable structuring criteria for storing content. Further mode, a mechanism has to be found which allows the identification of that content necessary for making a decision within product development activities or for continuing the product development process respectively. Similar to the product model representing the content describing the product which actually is developed (see chapter 4.1) a model of a content warehouse is needed which supports the structured identification and storage of all kinds of relevant content which has been created in former product development projects or which origins from other content sources such as the research department, the sales and services department, or conferences. This model has to provide a clear structure which also can be dynamically extended according to the demands of the product development organisation.

The knowledge roadmap also needs a clear structure which helps to identify the information needed. This information primarily is meta data referring to specific content sources and content-bearing persons and describing which kind of content and which information objects these sources and persons possess. The structure of the knowledge roadmap e.g. could consist of different layers representing specific kinds of content sources. According to these layers there could be a matrix structure representing the different kinds of content on the one hand and the information objects representing the content on the other hand.

Summing up, the adaptation of the two knowledge management methods chosen as examples mainly is done by the definition and installation of a suitable structure for storage and administration of the particular content respectively meta data. This structure has to be able to store and administrate this content and meta data independent of a specific product development project.

## 6.3. Methods' Use

The use of the two methods described is initiated by specific product development process steps respectively by specific interactions preceding these specific process steps. The aim of the methods' use lays in gaining additional data, information, or knowledge to carry out the specific product development process step more efficiently. The interacting persons use one of these methods when they expect a benefit from this utilisation. When a combination of the content created throughout the core product development process with the content stored in content warehouses or when involving persons with specific competencies who have been identified via the content roadmap leads to really new content needed for a decision or for processing a specific product development process step the aim formulated above will be achieved.

The utilisation of the content warehouse requires a suitable instrument or tool for identifying and finding exactly that content stored in the warehouse that is needed. Thus, the actors searching for specific content in the first step have to identify the content respectively the information objects they are looking for. In the second step, they will extract this content out of the warehouse by using the mentioned instrument or tool which can be kind of a search engine. In the third step, finally, they bring the extracted content into the product development process by using it to carry out a specific product development task or by combining it with content already created in earlier steps of the development of the particular product. So, this content which origins from other sources than the respective product de-

velopment process is integrated into this process to carry out a specific process step quicker, more efficient and more effective.

The content roadmap in contrast to the content warehouse does not store specific content but it shows where this specific content can be found or which persons are in charge of specific content or competencies. The persons interacting within a particular product development process step, firstly, have to identify the needs of content or of competencies necessary to make a decision within this process step or for continuing it. When these needs are identified they can use the content roadmap which according to its structure allows a quick identification of the content sources or the persons with the needed competencies, respectively, via the respective meta data. In the next step, the needed content is acquired directly from the content sources or the needed competencies are directly asked for at the particular prevailing person and brought into the specific product development task, so that these tasks also will be carried out quicker, more efficient and more effective.

The use of the two content management methods described does not really differ from the use of the original methods taken from the field of knowledge management. The most important difference is that these methods are of a much higher complexity than the original methods, so that they strongly demand very clear structures as well as suitable instruments and tools to navigate within these structures. These instruments and tools still have to be developed. They partly depend on the structure of the particular described content management methods which from the author's point of view could be represented by an XML scheme. This scheme could determine such a structure on a rather abstract level and could serve as a reference structure for content management methods requiring such a structure.

## 7. CONCLUSION

The content management framework described in the paper at hand represents a suitable model which helps to structure and to arrange the sub-models, methods and devices as well as systems, instruments, and tools relevant in a content management context. This framework gives no detailed description of these elements; it rather shows how they are positioned to each other and how they interrelate.

Future research, firstly, must result in a detailed description of some of these elements. So, reference models for the product representation as well as for the product development process representation will be developed and described conceptually. Further more, suitable schemes will necessarily be erected which allow an illustration of these models in electronic formats, so that they can be realised via software systems and tools. Similar concepts and schemes also have to be developed concerning to all the other methods, instruments, and tools to be arranged within the content management framework.

Before this development work can be done, these methods, instruments, and tools relevant in a content management context have to be identified and brought into a structure. Besides the conceptual and electronic representation of these methods, instruments, and tools also tools and devices have to be developed and described electronically which support the use of the content management methods, instruments, and tools respectively the access to the content stored in some of them.

Summing up, a lot of development work hast to be carried out to fill the content management framework completely. Thus, a particular research field can be set up which covers this research and development work.

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