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Interweaving Knowledge Acquisition and Product Functionality

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Abstract: This research is concerned with the detailed study on Product Functionality and to select a Knowledge Acquisition Method for Acquiring Knowledge on Product Functionality efficiently. The purpose of this research is to ensure that important aspects of product data are taken into account in knowledge management projects. The most important venture of this research is to design a questionnaire for acquiring knowledge on product functionality, and then test the designed questionnaire with certain industrial product data collection.

Keywords: Knowledge, Product Functionality (PF), Product Knowledge, Knowledge Acquisition (KA), Bill of Materials (BOM)

1. INTRODUCTION

This research is concerned with the process of Acquiring Knowledge on Product Functionality efficiently. A product must perform to meet customer needs and the functional requirements to capture the intended behavior of the product - what the product will do. This behavior may be expressed as functions, tasks, or services the product is required to perform. In order to be successful in a global market, a product developed must provide better functionality to its users in comparison to the current products. This research paper analyses the product introduction process in order to identify basic element, relationship of a product in an organization. It also presents a fundamental structure for understanding product functionality and the prerequisite for their integration. The main objective of this paper is to acquire knowledge on product functionality using industrial product data collection.

A product is an object developed by human or mechanical effort or by natural process. It can be anything produced as a result of generation or growth or labor or thought or by operation of unintentional causes. A product is viewed upon as a technical system, which is as a set of interrelated subsystems or machine elements comprising a whole article that intends to achieve a particular function [Maryam A and Dorothy E, 2001]. A product not only depends upon one single function, but also on a sequence of key functions, which together describes its worth. In order to have control over the diverse goal of a new product development process, functional and physical integration of the product is very vital. Experts define a product's functionality as a set of rules/goals to identify product features, benefits, purpose and use. It represents the progress of a product that can be recognized and experienced by consumers.

2. PRODUCT FUNCTIONALITY

A product can be described from many different points of view, each potentially defining a different product structure. A product is designed and developed according to a specific product structure. A product structure called Bill-of-Materials (BOM) is a collection of component descriptions organized as a part of functional hierarchy. Each component description contains the necessary information for making a piece of the product [Tomi M., et al.]. Functionality is an abstract product characteristic that a customer or sales person uses to describe what the product can be used to do and what requirements the product can satisfy [Alexander et al. 2001].

There is an emerging need for enhanced support of development processes in computer-aided theoretical design of various kinds of products, ranging from day-to-day appliances to industrialized systems. Possibly, the most vital stage in a product life-cycle is the phase in which the product is utilized by users, and intended to perform its implicit functions. But the issue is to recognize why products often fail to offer the intended function to users' satisfaction. This issue must be regarded in the perspective of the budding use of knowledge based systems in support for better designing of products.

Rapid changes in market requirements compel businesses to develop customized product with cost and time efficiency of mass production. Due to lack of standardized product functionality knowledge acquisition methods, in-depth product knowledge such as BOM, functional dependencies, assembly constraints and configuration rules cannot be managed effectively. A product developed long time ago under the assumptions of its functional effectiveness at that time can be reused in business years later for better advancement. Functionality is the most important property of a product, i.e. if the product does not possess right functions then other properties are uninteresting [Mortensen and Hansen, 1999].

2.1 Product Structure and Bill of Materials

The product structure provides a hierarchical classification of the items which form a product. With the product structure, the understanding of the components which compose a product as well as their attributes can be represented. The product structure shows the material, component parts sub-assemblies and other items in a hierarchical structure that represents the grouping of items on an assembly drawing or the grouping of items that come together at a stage in the manufacturing process [Adapted by DRM Associates from the CONFLOW Project, Nov 2012]. Product structure management provides the mechanism to capture and manage as-designed product structures with ease. It allows for the creation and re-use of unlimited numbers of parts and assemblies, to provide for many different variations of a basic structure or the creation of complex, one-of-a-kind structures.

In Fig.1, a product named 'Product 1' is shown graphically with the summarized products structure and the number of all items that are needed to make the parent products are enclosed in brackets. The product structure diagram which is used to create a version of the product to sustain development and the BOM capture the relationship between the components of a product [Adapted by DRM Associates from the CONFLOW Project, Nov 2012].

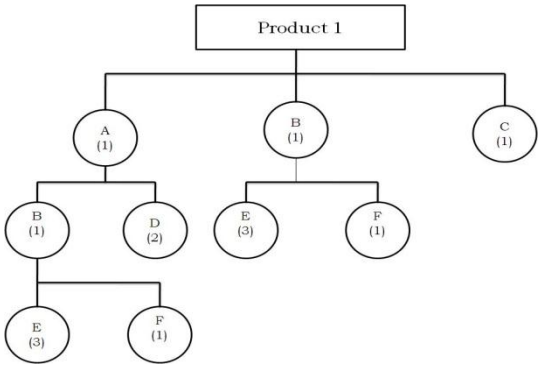

Figure. 1 Product Structure [Adapted by DRM Associates from the CONFLOW Project, Nov 2012]

A Bill of Material is a formally structured list for a product which lists all the component parts of the object with the name, reference number, quantity and unit of measure of each component. A BOM can only refer to a quantity greater than or equal to one of an object. It is a product data structure, which captures the end products, its assemblies, their quantities and relationships. It is a product data structure which captures the end-products, its assemblies, their quantities and relationships [Adapted by DRM Associates from the CONFLOW Project, Nov 2012]. There are usually two kinds of bills of materials needed for a product: engineering and manufacturing BOM. The engineering BOM normally lists items according to their relationships with parent product as represented on assembly drawings. But this may not be sufficient to show the grouping of parts at each stage of the production process nor include all of the data needed to support manufacturing or procurement. These requirements may force the arrangement of the product structure to be different in order to assure manufacturability [Adapted by DRM Associates from the CONFLOW Project, Nov 2012].

2.2 Function Structure and Sub-Functions

Function is a relationship between input and output of energy, material and information [Tomiyama 1993, Qian and Gero, 1996]. Product function is an effect on the environment of the product. The functions are themselves described as structures that are defined at the instance level [Shaw, 1989]. Function is a higher level of abstraction than structure, and helps to capture the designer's intent [Tor et al., 2003]. A function is primary if you can associate it with the purpose of the product and it is essential to that purpose. Primary functions define the product. Groups of functions, taken together, may constitute a primary function, too. Any function that contributes to the utility of the product but that is not a primary function is a secondary or sub function.

Functionality is the ability of the product of function. The Actual Product Function is in concert with force flow analysis. In a conceptual design the functional structure of a design object is determined and the basic physical mechanisms that realize the function structures are also determined [Tomiyama, 1993]. Functionality is the most important property of a product, i.e. if the product does not possess right functions then other properties are uninteresting [Mortensen and Hansen, 1999].

2.3 Functional Requirements

An abstracted description of work is that a product must perform to meet customer needs. Functional requirements capture the intended behavior of the product- what the product will do. This behavior may be expressed as functions, tasks, or services the product is required to perform. Therefore, functional requirements do not include performance characteristics, operating conditions, use cases, and specifications. The information that is supported is in the form-features cannot be obtained easily. The functional requirements of a system will be capable of overcoming these deficiencies [Shah, 1988].

2.4 Functionality Dependencies

The product's functionality depends on the product features relevant to the target market. Critical topics include prioritization of functionalities and capabilities based upon market demands. The functionality of the product plays an important role in the technical process. At any stage of the process it is necessary to see whether the product's functionalities have been achieved. Based on this the decision about the direction of the project, the resources required to achieve the product functionalities would be planned. The functionality of the product is treated as the separate element from the product itself. Thus, functions during technical process are achieved through specifying and identifying changes in the attributes of the product elements and relationship between the product elements [Thirupathi, 1998].

3. INTERWEAVING KA AND PF

Knowledge management of new product development provides an approach to represent and manage product domain entities and relations. KA is depicted as the major problem in illustrating the functionality of any product. But the complexity of the product descriptions in certain businesses causes difficulty. The product engineers/developers can no longer understand a product the way it is portrayed. The problem is due to brief addressing of the configuration product structure models in the object oriented methods look more comprehensible than its detailed functional components.

Knowledge management in product development covers a broad spectrum of activities and operations at many levels, from the individuals to the whole enterprise and between enterprises. Effective KM can only be achieved through a holistic approach, addressing not only technological solutions, but also people, processes and links of core business activities. The purpose is to reuse knowledge, create worth in enterprise, create new knowledge by any possibility, and thus provides economical knowledge mobility for the circle of knowledge management. Knowledge management is a gradual and circular process in knowledge-based product development system as shown in Fig.2 [Li and Xie, 2004].

In practice, there may not always be intent, or even an ability, to use archived product knowledge to automatically generate new design solutions. Nevertheless, whether the goal is automated synthesis or computer-supported designer synthesis, the basic need to retrieve and reuse knowledge in subsequent design activities remains the same. From this

perspective, the common requirements are to take as input some articulation of a target design or specification, to retrieve previously generated knowledge according to some measure of similarity, and to evaluate multiple potential matches to determine which most closely meets the specification [Li and Xie, 2004].

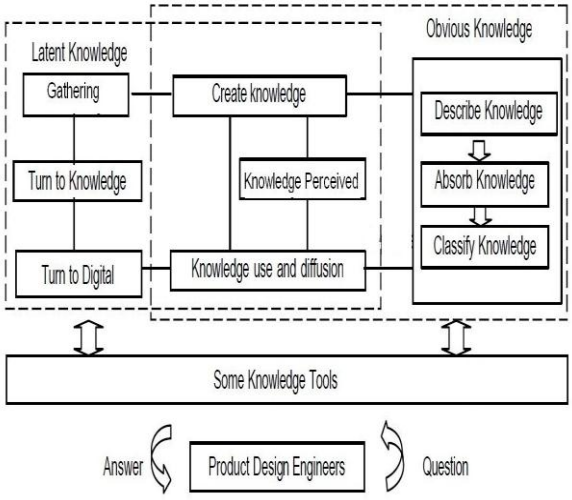

Figure. 2 Process of Knowledge Acquisition in Product Development [Li and Xie, 2004]

3.1 Industrial Knowledge Acquisition

Knowledge is also embedded in the technologies, methods, and rules of thumb used by individuals in a product development processes. KA is invested in the methods, ways of doing things, and successes that demonstrate the value of the knowledge developed. The knowledge in new product development is localized around particular problems faced in a given platform. The effective development of knowledge in organizations demands that individuals specialize or localize around different problems in a specific domain [Paul R. C., 2002]. It is important that KA techniques are extended to cover not only the static knowledge about a product, but also the dynamic knowledge about the design processes of the product. Due to their high complexity, product development processes should be expected to be a highly rewarding field for the application of knowledge management [Christian W, et al., 2004]. The lack of a proper product representation which includes its function, behavior, and structure is a foremost limitation of the existing systems.

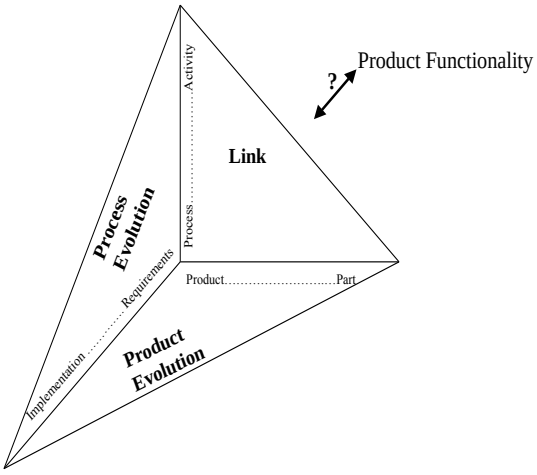

Figure. 3 Dimensions of Product Development Process [Thirupathi, 1998]

Table 1. Product Functionality Sample Data Acquired

Sl. No.	Product name	Components	Functions	Primary / Secondary
1.	Mobile charger	Insulation wire	For power supply connection	Primary
		Regulator	To stabilize the voltage supply	
		Rectifier	To convert from AC to DC	
2.	Microwave Oven	Induction coil	To produce heat	Primary
		Ventilator	For cooling the system and processing air supply	
3.	Air Cooler	Gas Container	×Not Specified	Primary
		Filter Paper		Secondary
		Cooling Fan		Primary
4.	Pen	Refill	Used to contain ink	×Not Specified
		Ink	To write	Primary
		Plastic	Acts as outer body	Secondary
5.	Sin-treed Component	Gear & Gerotors	×Not Specified	×Not Specified
		Hubs		
		Piston		
		Bearing		

An optimal use of the resources such as people, computers and machines requires that they are part of a system which able to master the action flow and the information flow. Mastering action and information flow improves the quality of the products, due to avoidance of errors and increased production flexibility. The quality of a product depends on the functionalities that it provides. Even though achieving product functionality is an essential goal and is the key to the success of a new product, there is no model in the related areas that considers product functionality and its relationship with the process that introduces the product; the semantic link (goals, control) between the product functionality and process have been vastly ignored. Modeling methodologies should tackle this problem of modeling product functionality in order to control the Product development process effectively. In large enterprises, new products that have high market value are produced by embedding product development processes and knowledge acquisition techniques to make sense of the system. The effectiveness of a product developed depends on the privileged circumstances of the knowledge that design experts bear in solving problems and the probability of trying innovative methods and generate new interpretations. None of the candidate architectures and associated methodologies is, as yet, completely developed, described and documented to address ← the goal (product functionalities) view of the process, ↑ the link between the process and its goal, → evolution of information and ↓ the link between the process and its output (Fig. 3) [Thirupathi, 1998].

The product knowledge of an enterprise can operate as a bond for integrating processes that are carried out in various domains. Mastering product functionality data allows a better integration of the product development process. For acquiring product data and its functionality, manufacturing companies involved in new product development process have been considered. In order to acquire this product knowledge, a questionnaire has been designed. The sample size of the data acquired is thirty corresponding to different products. The questionnaire gathers creditable information about the product data such as:

- Name and segments of the product
- Specifications and purpose of the segments
- Assembly/Component functions
- Functionality of the product
- Parameter used for rating the product and
- Electronic storage details of the product data and product functionality

The gained product knowledge corresponds to thirty products from thirty different design engineers. Each product has its own purpose, specification, assembly/components and functions. The designers have produced few details about each of the components in the product and their functions. This product data collection gives a concise breakdown of the product functionality details obtained via the sample data which explains briefly the various functionalities of the given product. It enlightens the various products, its assembly and function data acquired through questionnaire.

3.2 Analysis of Product Functionality Data

This analysis is useful in study the data based on segments, components, functions and parameters of a product and its functionality. The collected product knowledge corresponds to thirty products and they can be categorized into three branches of product data storage. The product data storage can be sorted out into data which are digitally stored, which are not stored digitally and which details about storage are not specified.

In Table 1, the column “product name” lists the different products whose production data has been acquired. The column “components” lists the different segments of the product. The column “functions” and “primary/secondary” illustrate the various product functions and its rate accordingly. The × mark in the table shows that many designers are unable to explain or the knowledge on the functionalities of a product is less among the designers.

Table 2. Product Functionality Data Storage Analysis

DATA STORAGE	DATA SIZE (30)	PERCENTAGE (%)
Data Not Specified	19	63%
Stored Data	3	10%
Data Not Stored	8	27%

From the table 2, it concludes that only 10% of product functionality data is stored digitally and approximately 90% (No knowledge of storing product functionality data=63%, and product functionality data not stored=27%) of designers do not store functionality information digitally. The fig 4 is a pie-chart that represents the facts about functionality of a product’s data storage.

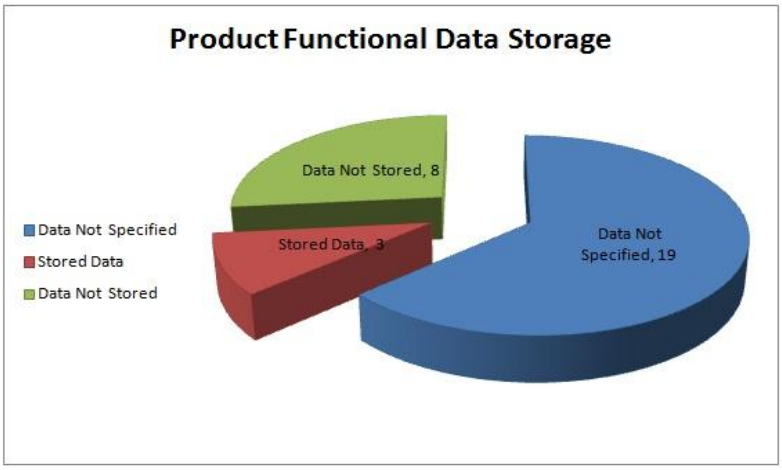

Figure. 4 Product Functionality Data Storage Analysis with Samples Data of Size 30

4. RESULTS AND DISCUSSIONS

Knowledge is one way by which individuals exhibit their proficiency in solving problems i.e., being a good design engineer to meet all the customer requirements. Product functionality designing is essential to describe the generality in product structures. When a design engineer sees the significance the current design has on creating an effective product, it will be necessary to transform that knowledge into a working prototype. Hence, experts have need of a general technique or tool that ensures consistency and offers appropriate mechanisms for mass data processing for integrating knowledge management and product development.

A conventional type of product knowledge comprises of product design skills, process scheduling experiences, management artifice, and market necessity information. The purpose of product functionality is to represent product family through a general design structure. Actually it is a process that acquires and represents product knowledge briefly with its functional structure. This depicts the components that are needed for a product, the quantity of components and their dependencies. This assists the design team to identify and rank areas of focus for product improvement.

Engineers engaged in product development bring to their work the formal and articulated expertise that has been socially constructed through time by particular professional or academic communities. This knowledge initially frames attention when approached with a problem; however, by making sense of particular problems and of the information encountered in particular situations, and by taking action and revising their interpretations, new knowledge both tacit and explicit is developed. This form of collective sense-making, entailing personal links between people with different knowledge can yield new knowledge [Susan et al., 2003].

5. CONCLUSION

This research is an outcome of selecting a knowledge acquisition method for acquiring knowledge on product functionality efficiently. It highlights about a product, its functions and sub-functions, its overall functionality while developing a new product. The product functionality data is not stored digitally. Most of the design engineers are unaware of the importance of product functionality and relevant associated data; they concentrate only on the physical design of a product in the development process. In due course of time, if the product is not manufactured in bulk quantity, then the knowledge about product functionality and hence the product may disappear.

It concludes that most of the design engineers are unaware of product functionality. Those who have knowledge about the functionalities of a product do not store them digitally. Those who store product data do not store product functionality data. It affirms that only one in a tenth digitally store the functionality data. In order to overcome this issue, it is necessary to cultivate knowledge in the minds of designers to store every minute functions and parameters of a product during the development process.

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