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Procedia Manufacturing 24 (2018) 2–7

Procedia MANUFACTURING

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4th International Conference on System-Integrated Intelligence

A case study for a unified designation of development information in a PDM System for Technical Inheritance

Wieben Scheidel*[a], Iryna Mozgova[a], Prof. Roland Lachmayer[a]

[a]*Leibniz Universität Hannover, Institute of Product Development, 30167 Hanover, Germany*

Abstract

Industry 4.0 is the next step to autonomous products, productions and processes, which have the ability to collect information about themselves and their environment and to communicate with each other. The information about the products is analyzed and verified to develop a new product generation, what is called Technical Inheritance. The information about the product are saved in databases, which storage the information but do not structure them. For a unified designation and organization in the development phase Product Data Management (PDM) systems are used. The following paper presents a numbering system, which ensures a unified designation for the Technical Inheritance. Shown on a sorting system for object carriers in a medical environment the numbering system demonstrates, how the Technical Inheritance is implemented and traceable in a PDM system.

Keywords: Product Data Management, Technical Inheritance, Numbering Systems, Industry 4.0

1. Introduction

On the one hand development times are shorten and companies need to bring new products to the market as soon as possible. This leads to the situation, that product developers need a fast and practicable option to get an overview about exciting technical solutions to work effective and to fulfill the demand of a fast product development. On the other hand products are more and more digitized, where information can be collected and deployed [1]. The term digitalization or Industry 4.0 is often put in touch with a self-organized and networked production and logistics

* Corresponding author. Tel.: +49 (0) 511 762-4507; fax: +49 (0) 511 762-4506. *E-mail address:* scheidel@ipeg.uni-hannover.de

10.1016/j.promfg.2018.06.002

connected by information- and communication technology [2]. With modern approaches for Industry 4.0, like Industry 4.0 and more, is not just the storage, saving and converting of information from the production and logistics considered, but also the entire product lifecycle including usage and development phase [3]. The information are analyzed, verified and reused in the product development to create a new product generation. The approach of creating new product generation based on lifecycle information and experience from previous generation of products is called Technical Inheritance [4]. Data and information that are collected from products with the help of Industry 4.0 increases next to conventional product information and are saved in databases, where they need to be structured so product developer have the possibility to find needed information in a short amount of time, to use and adapted them. Therefore a unified designation and structure for product information is necessary. A possible solution for structuring, managing and designating product data are Product Data Management (PDM) systems, which are databases with a few preinstalled functions and used as the state of the art in product development. Therefore a PDM system has to be adapted to the needs for Technical Inheritance. This paper treats the topic how products need to be designated within a PDM system, so a continuity and a traceability for Technical Inheritance is created. The following section 2 provides a brief overview over the concept of Technical Inheritance and definitions. Section 3 contains a review of PDM Systems and numbering systems. Section 4 presents an approach to structure product information for Technical Inheritance. Then section 5 contains a case study in which the approach is applicate on a sorting machine used in a medical environment. Section 6 contains a brief summary and an outlook.

2. The Concept of Technical Inheritance

Technical Inheritance is defined as a transfer of assembled and verified information from development, production and application to the next product generation [5]. Based on collected and verified information components are adapted and optimized for the next generation. Deduced from evolutionary mechanisms from nature mechanisms for the evolution of technical products are adapted and determined [5, 6]. Within the Technical Inheritance are defined different terms:

1. The Technical Evolution is a process of control, stepwise and continuous change of technical systems, products and processes as well as models with the aim to adapt to influences and requirements.
2. The Population consists of all generation of individuals of a technical system, product and process as well as a model at the current time.
3. The Generation is a group of individuals with the same level of development.
4. The Genotype is a model of a Generation that describes the entirety of parameters. Modifications are made on new requirements, market needs and new technologies.
5. The Individual is the smallest considered technical system, product, process or model in a population.

In Figure 1 the Technical Evolution is depicted at the example of the VW Golf. All cars from the Golf I to Golf VII build the population.

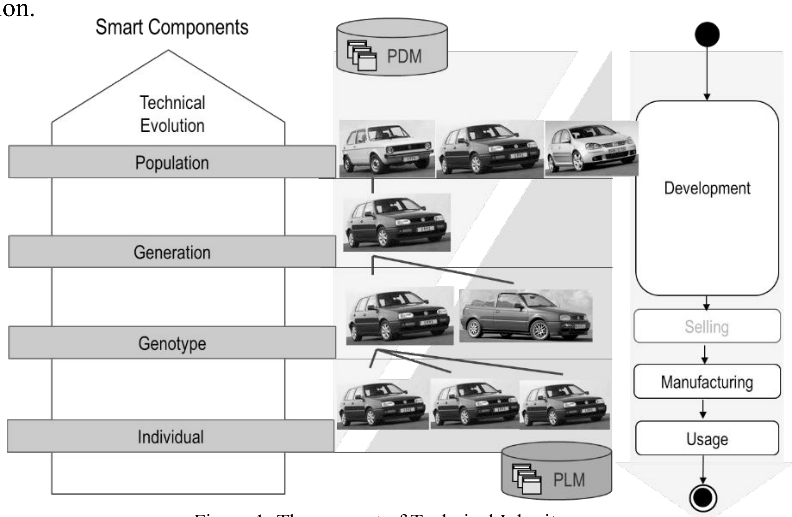

Figure 1: The concept of Technical Inheritance

The Generation is represented by one specific Generation, e.g. VW Golf III. During the time the VW Golf was sold, special editions, e.g. VW Golf III Bon Jovi, were released. These cars are modified in single areas, e.g. a modified antilock braking system. From the Population to the Genotype all cars are implemented in the development. All produced cars with a usage phase are Individuals, because they experience unique loads. The product information about the Population are implemented in a PDM system. In every Population is at least one Generation, where all information are also archived in a PDM system. Genotypes and Individuals are characterized by the fact, that they receive more information and experience during their lifecycle, which are not implemented in a PDM system, but in a Product Lifecycle Management (PLM) system, where information e.g. about manufacturing and usage are saved.

3. State of the Art

The development of product generation requires consistent, structured and continuously information. It is provided to the developer as a tool in product creation and serves as an integration platform for various development systems (e.g. CAX-Systems or text processing Systems) [7]. It is used for the management of computer-generated 3D models, drawings and further development and product relevant documents [8]. The basic functions of PDM technologies are divided in five sections [9-13]:

- Document Management includes the creation, revision, changing, control, allocation and archiving of documents are organized by the document management function.
- Product Structure Management includes the relationships (belongs to or consists of) between single components and assemblies are built in a hierarchically structure
- Workflow Management includes the business processes and workflows can be created, controlled and represented with in PDM system.
- Project Management includes timetables, activities and project management information, e.g. project specific roles, mile stones or stakeholders, are administrated in the project management.
- Classification includes classification systems are numeric systems that are used to arrange objects according to their features, which describe and difference them from others. With classification systems the identification of objects is possible. Numbering systems are part of the PDM function Classification and are used for a clear assignment. Its tasks is it to identify objects and to classify them. The benefit of using a numbering system is a clarity, order and standardization of information [10].

A number is used to identify an object that means the object has a clear and an unmistakable recognition within a field of application, e.g. an article or material number for a single component or an assembly [11]. The second task is to and to arrange objects according to their features, which describe and difference them from others [12, 10]. It is differentiated between (1) identification numbers, used for a clear and unmistakable recognition that can be searched for, (2) classification numbers, which sum up features to arrange a group of objects and (3) information numbers.

Essentially two system forms are differentiated, on the one hand the compound numbering systems and on the other hand the parallel numbering systems. Compound numbering systems include a classifying part and a counting number.

The second numbering system is the parallel numbering system. It contains an identifying and classifying part. For the identification a counting number is used, which is unique, assigned for exactly one object [8, 9]. The classifying part is diverted into two parts. First comes a rough classification, which sort objects by one to two features. The fine classification is used to sort the objects by more features and to distribute them in smaller groups. Both scheme are depicted in Figure 2.

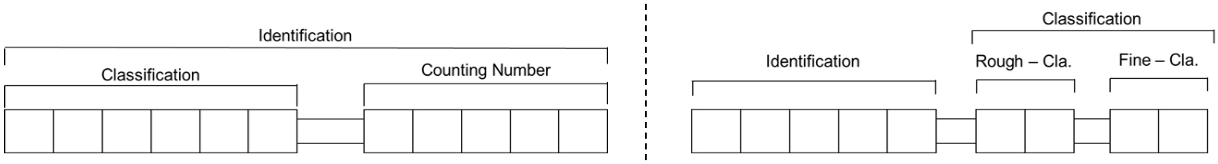

Figure 2: left: compound numbering system – right: parallel numbering system

4. Method for the implementation of Technical Inheritance in a PDM system

The aim of the method is, to designate development objects within a PDM software, so a continuity and a traceability for Technical Inheritance is created. Therefore, the parallel numbering system is most appropriate, as first the Technical Inheritance is usable for different objects with different features and the parallel numbering system can be adapted to the different features. As second objects can change within in the Technical Inheritance in an unforeseen way based on what they experienced during their lifetime and the parallel numbering system is flexibly adaptable. The numbering system is also appropriate, because the classification part can display which Generation and Genotype the object owns.

However, the parallel numbering system consists of digits and does not contain a verbal description for a better understanding. Therefore the numbering system is expanded with a verbal description part between the identification and classification part. To represent the Technical Inheritance clearly the classification part is used. The rough classification represents the Generation of an object and the fine classification part represents the Genotype of an object. That supports the traceability and hierarchy of the product generations and makes visible what the origin design is. For the identification part a counting number is used.

A PDM system is a database in which different information about an object are contained [9]. So the information need to be assigned and connected with each other. Therefore the numberings system is used as a kind of container to which all development information are assigned. That offers the advantage, that information about an object is not bounded to a CAD model or a drawing, but every information that is generated during the development can be found with the identification number. In Figure 3 the scheme of the numbering system is depicted.

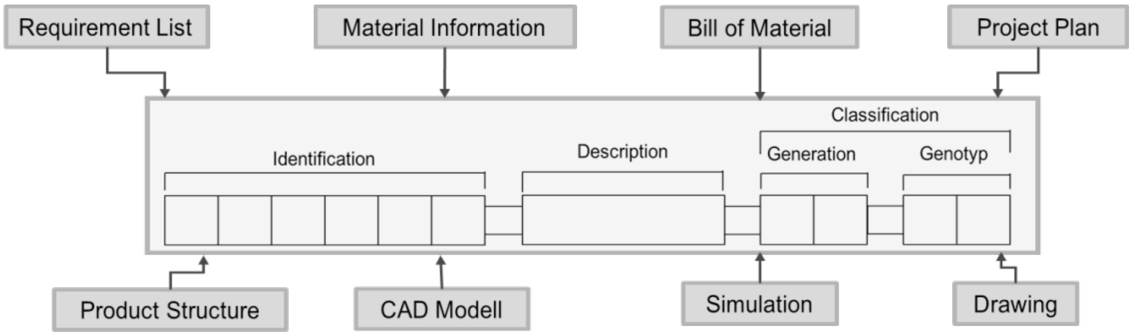

Figure 3: Numbering system for the Technical Inheritance

When every object in a PDM system has its own number, the development within Technical Inheritance is traceable. The first object starts with its unique identification number, followed by the description and ends with the classification of the first Generation and the first Genotype. Information about the object are saved under the number and are connected with links in the PDM system. All development relevant information are saved in one project folder. Furthermore, the collected and verified information about the lifecycle can be assigned to the Generation and is provided to further developments.

After collecting and verifying the first Generation’s lifecycle experience the second Generation is developed, based on the first one. The development information, e.g. the design, solution principles or material, and the relevant conclusions from the lifecycle are transferred to the second generation’s development project in a separate project folder. The knowledge and the experience are saved and the next generation is based on the existing model. To avoid to inefficiency after some time because of the amount of data, to every time a new Generation or a new Genotype only the relevant information are transferred. If more information are needed about a specific Generation or Genotype the development projects are linked between each other.

5. Case Study

For the case study a sorting system for object carriers is chosen as a demonstrator. The sorting system, depicted in Figure 4, is used in a medical environment of a hospital, where object carriers are sorted manually by a number from 1 to 1000. To relieve the laboratory staff, the sorting system was developed and manufactured by the Institute of Product Development. The object carrier is taken by a pneumatic gripper from one of four separators and is transported by a room portal to 1 of 1000 slots regarding its scanned number. Object carriers with no number are placed in a waste area. The movements and the usage of the room portal can be detected and saved on an external storage medium.

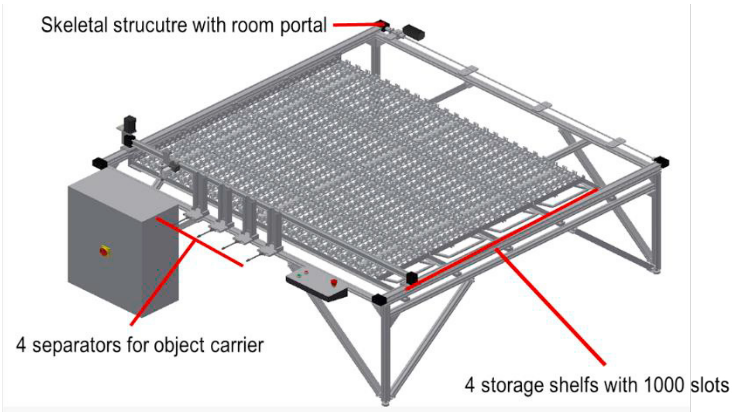

Figure 4: Construction of the sorting system

During the development all product information are placed in a project folder *Sorting System-1* within the PDM system Autodesk Vault Professional. For a better distinguish and traceability within the Technical Inheritance the Generation is named in the folder description. The assembly and the components are determined as a basis from which the following Generations and Genotypes are deduced. For the sorting system a project plan was implemented, the product structure was generated according to the CAD Modell, the documents were sorted into the PDM system and all assemblies and components got an identification according to the parallel numbering system. Therefore an individual number, a description according to the component or assembly, the Generation and the Genotype were determined regarding to the expanded parallel numbering number.

During usage information about the system are record, which are useful to develop the next Generation in a shorter amount of time and to determine the product requirement more precisely and quicker than in the development phase before. Therefore the usage information are stored in a file, which is saved and provided in the project folder of the *Sorting System-1* and can be updated regularly in the PDM system. During usage it was recorded that object carriers were found in the wrong slots. This information is stored in the usage information file in the PDM system and saved for the next Generations. According to the Technical Inheritance a new product Generation is developed on analyzed and verified lifecycle information from the previous generation.

The analysis showed that he room portal and its steerage worked properly, but the design of the carrier holder for the slots of Generation 1 were too small. Hence a new Generation for the carrier holder needed to be developed. The development information, e.g. project plans, CAD models, drawings, from the carrier holder Generation 1 – Genotype 1 with the identification number 598662 were selected and copied into a new project folder within the PDM system for the carrier holder Generation 2. For an unequivocally designation the new identification number 621856 was determined, the description and the Genotype is kept, but the Generation is counted up. With the quick available development data in the PDM system and the analyzed and verified usage information the requirements for the new development were set in a short amount of time and the developer designed effectively the carrier holder Generation 2. Within the CAD Model a greater chamfer was designed, so the object carrier cannot fall slip into the next slot and so some inaccuracies of the pneumatic gripper are counterbalanced, shown in Figure 5. The new component the drawings were adapted and linked to the new object number.

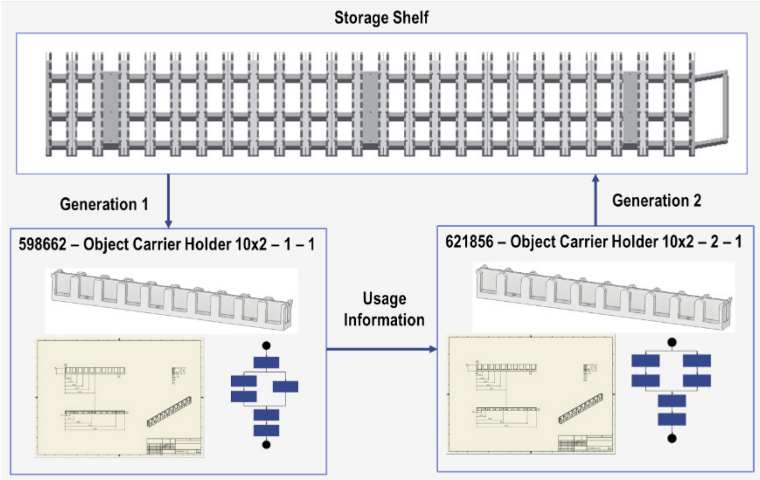

Figure5: New Generation according to Technical Inheritance for the object carrier holder

6. Summary and Outlook

The paper showed that for an efficient and fast development of new products structured clearly designated information, storage in a PDM system, are needed, which can be taken over and adapted. For a clear understanding and traceability a unified designation by an expanded parallel numbering system is used. Within the case study of a sorting system for object carriers the application of the numbering system is shown and that analyzed and verified lifecycle information are used as knowledge to generate a new product Generation according to the Technical Inheritance. The next steps will be to work further on the analysis of the usage information from the sorting system to identify and to improve deficiencies.

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