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Development and first applications of gentelligent components over their lifecycle

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ABSTRACT

The separation of a physical component and its corresponding information contradicts the successful implementation of new applications over the lifecycle of the component. However, this obstacle can be overcome by means of gentelligent components with enhanced capabilities in terms of component-inherent information storage or decentralized communication capabilities. Focused on a number of applications for the design, manufacturing, and maintenance of gentelligent components, the following paper demonstrates the advances and advantages of gentelligent components and systems over their lifecycle. The scope of the paper includes novel technology for information storage, information generation and monitoring as well innovative methods for the design and maintenance of gentelligent components.

1. Introduction

The recent shift from mass goods to individualized products has drastically increased the required product specific data storage and data management effort. Lately, product-relevant information needs to be exchanged not only between the different in-house departments of a given manufacturer but also between customers and suppliers. Furthermore, the individualized production process itself results in a significant amount of product-related information within the framework of constantly changing production parameters [1,2]. Hence, the amount and variety of information to be exchanged have increased considerably and – more importantly – are expected to continue their rise in the future [3], as the market demands improved traceability of individualized products, starting from their primary material source over the production to their distribution and implementation. Additionally, enterprises with distributed manufacturing resources aim for high visibility and traceability of their products during the manufacturing process in order to support their real-time collaborative manufacturing decisions [4]. For this purpose, production enterprises have started exploiting the potential of the available information technology, such as Radio Frequency Identification (RFID). In the case of cost-intensive or security-relevant components, individualized identification methods, e.g., Data-Matrix-Codes or RFID-Tags, have become a standard in industrial production [5]. By applying the identification mark directly onto the component, a fast identification and tracking of related product information is provided [6]. However, access to product-specific data is often possible only for the product manufacturers, since only they can access the central information servers where such data are stored. Later on, such data must be generated with much effort.

The Collaborative Research Centre (CRC) 653 "Gentelligent Components in their Lifecycle" provides a novel approach to storing component-relevant lifecycle information inherently into the component. Gentelligent is a portmanteau word that combines the attributes of genetics and intelligence abilities in one adjective. Gentelligent components are able to feel, communicate and store information from their environment and, thus, act as autonomous intelligent individuals [7]. Based on this technology, real life information becomes available and can be used over the entire lifecycle of the component, providing advantages for many applications in production, application, individualization of components or a design improvement for the next generation.

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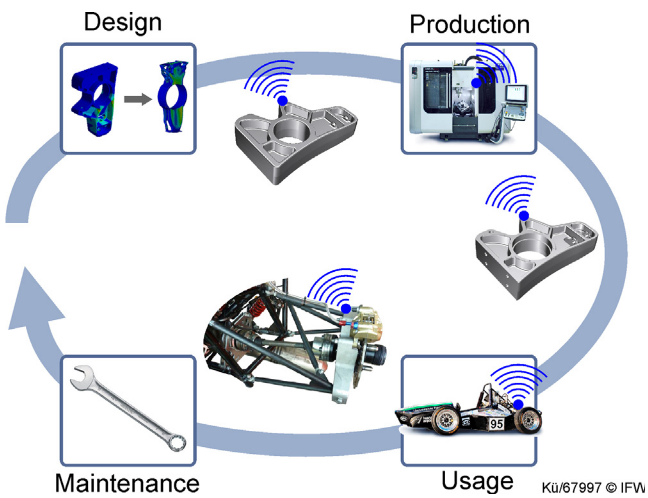

Fig. 1. Applications of gentelligent component over their lifecycle.

This results in a closed information loop whereby all relevant data – e.g., production data, load information from the usage and maintenance as well as damage information – are transmitted over the course of the lifecycle of the component as one data format, stored inherently in the component. Fig. 1 demonstrates this information cycle by means of an exemplary car component. Over its lifecycle, the gentelligent component continuously acquires and transmits a growing information base, starting from its design, over the production, usage and maintenance stages and back to the next evolutionary design stage where it transfers its lifecycle experience to a subsequent component generation (Fig. 1).

This closed information loop over the lifecycle of the component as well as the inheritance of the lifecycle information provides several advantages and enables novel optimization methods for many applications. Furthermore, intelligent components enable tracking of product-specific information (e.g., production order) [8]. As a result, they can be used for adaptive process planning and control during the production phase [9].

This paper is focused on the application of gentelligent components in the production, usage and maintenance stages as well as on the advantages they offer for the evolutionary design of next-generation components. The following chapters introduce, among others, novel aspects of acquisition, storage, management and usage of lifecycle information of gentelligent components. Below, the basic technology of gentelligent components is presented.

2. Information acquisition and storage by gentelligent components

The capability for storing data is crucial to any information-driven technology. Component-inherent information storage, i.e., writing and reading data by exploiting the physical properties of a component itself, provides several unique benefits here. Using inherent recording methods, individual and confusion-proof data storage can be realized, linking single components to their corresponding data sets. Furthermore, inherent data records can be used to avoid mistaken part identification caused by the increasing diversity of components manufactured within the same process. Similarly, incidents during manufacturing can be attributed to the exact component which has caused them – a fact that can extremely important in case of later liability disputes.

Nonetheless, probably the most important advantage of inherent storage over external repositories is that all relevant information remains present over the entire lifecycle of the component. Following, the current lifecycle data format and inherent data storage technology are presented.

2.1. Information structure – gentelligent markup language

In order to transmit relevant component information over the whole lifecycle of the component, a unified, self-contained data format is developed. A modular approach instead of a monolithic

```
<?xml version="1.0" encoding="UTF-8"?>
<GIML xmlns="urn:sfb653:gimlv1.0"
      xsi:schemaLocation="urn:sfb653:gimlv1.0 ...>
    <Component>
         <ID>17</ID>
         <Material>EN AW 2014</Material>
         <Length>240</Length>
         <Width>150</Width>
         <Height>50</Height>
         <Operation>
                <Name>FaceMilling</Name>
                <Machine>Heller MCi 16</Machine>
                <Tool>191320-6</Tool>
                <Clamping>NM02</Clamping>
                <Time>58</Time>
                <Parameter>
                      <vc>125</vc>
                      <fz>0.025</fz>
                      <ae>1</ae>
                      <ap>10</ap>
                </Parameter>
                <Result>
                      <Force>102</Force>
                      <Rz>4</Rz>
                      <Deviation>5</Deviation>
                      <Temperature>105</Temperature>
                      <Stress>30</Stress>
                </Result>
         </Operation>
    </Component>
```

GIML header

Component-specific data

Operation-specific process data

Process parameters

Manufacturing results

Fig. 2. Sample GIML file: production log (excerpt).