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Utilising the Internet of Things for the Management of Through-life Engineering Services on Marine Auxiliaries

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Abstract

The producers of marine auxiliaries face the challenge, that they need to adapt their schedule for maintenance, repair and overhaul (MRO) operations and other Through-life Engineering Services (TES) to the otherwise defined and often not well communicated schedules of the ships, which are carrying their products. The management of the MRO operations is currently a manual and time-consuming effort and makes the creation of Product Service Systems (PSS) a tedious effort. To help overcome this – unnecessary – hurdle, this paper presents a solution approach and its prototypical implementation utilising the Internet of Things (IoT) to aid the marine auxiliaries' producers in the process of managing the product usage phase and its services. As data basis for the decision support, the constantly produced information of the Automatic Identification System (AIS) is used, and combined with Product Usage Information and enterprise data.

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Keywords: Internet of Things; MRO; Through-life Engineering; Product Service Systems; Marine Industry, Product Usage Information

1. Introduction

Through-life Engineering Services (TES) have become increasingly important for many producers of knowledge-intensive products over the last decade. Both with regards to the optimization of their products conventional usability as well as for unlocking new and complementary business models. [1] For the producers of marine auxiliaries, alone the scheduling of maintenance, repair and overhaul (MRO) operations is a task which is consuming substantial resources. With the more and more readily available Internet of Things (IoT) technologies, new approaches for decision support in the management of TES is becoming available.

This paper presents an approach based on two different IoT systems, the Automatic Identification System (AIS) and Product Embedded Information Devices (PEIDs) to foster intelligent management of MRO operations for marine auxiliaries and their producers. Based on the general motivation, related work and presentation of the methodology, a practical specification and implementation of a decision support system along two development tracks are presented. The paper concludes with a summary of the findings and an outlook to future work.

2. Background and Motivation

The procurement of MRO - and also other TES related - operations is regularly a process which requires physical access to the core product. For stationary deployed products this is already in many cases an issue because the product context needs to be altered, e.g. the production stopped. For mobile products, however, another dimension of complexity is introduced with regards to the management of TES operations like MRO scheduling: the product's changing location.

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For the producers of marine auxiliary components, the latter problem is even increased by the fact, that while their products may be important to the operation of the ship, they regularly do not have a high enough significance to influence possible schedules and locations. They are thus highly dependent on the defined schedules of the ship owning companies and subsequently need to adapt their operations planning to the ships' schedules.

Currently, the management effort used to overcome this dilemma is a time consuming and manual one. Ships which carry products requiring service are identified and the respective ship owning companies are contacted to ask for possible timeslots while in the roadstead. Coordination of MRO efforts over multiple ship owning companies and harbours is virtually impossible as the information are very short lived, which results in a plethora of redundant and unnecessary travels.

Some companies have already begun to utilize the information provided by websites like MarineTraffic [2] which present both historical and forecast data from the AIS system. However, this practice either binds the users to the consumer-oriented user interface offered for free or at little costs by the service providers or invokes high costs for data acquisition and integration into the enterprise systems.

The approach presented in this paper shows ways to combine data from various data sources like AIS and enterprise systems in a cost effective and efficient way to enable marine auxiliaries producers to intelligently manage TES on their products. Additionally, to the location based decision support, possibilities for the integration of product usage information are being investigated, leading to an approach with two development tracks, one for the acquisition of product location data and one for the acquisition of product usage information.

3. Related Work

The following gives an overview of the relevant state of the art regarding the main technologies of the topics Through-life Engineering Services and Internet of Things which are the foundation relevant to the methodology and solution approach described in the succeeding chapter.

3.1. Through-life Engineering Services

Through-life Engineering Services (TES) are a type of product extension services. They help guarantee the required and predictable performance of an engineering system throughout its expected operational life with optimum whole life cost. [1] In order to mitigate degradation, restore lost functionality and maximize product availability, they apply service knowledge from product usage, maintenance, repair and overhaul [3]. With this knowledge processes, such as future product design, product improvements, usage support, additional service offers or end-of-life decisions can be subsequently improved.

Many different concepts support the development and procurement of TES. For the development presented in this paper, the technical approach to Product Lifecycle Management, the paradigm of digitized products and the concept of servitization are key enablers for TES. They are introduced in the following subsections.

3.1.1. PLM – Product Lifecycle Management

Product Lifecycle Management (PLM) can be interpreted from the marketing as well as from the production engineering perspective. [4] The production engineering perspective often divides the product's lifecycle into three main phases: beginning-of-life (BOL), middle-of-life (MOL) and end-of-life (EOL). [5] The BOL comprises steps such as product development, production, and distribution while the MOL represents the use phase and the EOL the reverse logistics. BOL and EOL are regularly of little interest to the customer or end user, while the MOL is in direct interaction with the user. [6]

Frequent interaction between product and producer in the MOL phase is thus hindered by the customers. This is even increased in control and security sensitive industries like the maritime sector.

However, for closed-loop PLM it is crucial to combine information flows of as many product phases as possible. [7] For the integration of the MOL phase as the regularly longest phase technologies that enable product – producer interaction without customer involvement, technologies like the Internet of Things (IoT) need to be employed.

3.1.2. Digitized Products

Informatization is referring to the process of collecting, storing and analysing data from customers and end-users of products and services and often serves the goal to discover new needs or identify changes in usage patterns enhancing existing offers or the related service-level agreements (SLAs) back to the customer. [8] It is systematised as an information feedback loop beginning with collecting and storing data from customers, analysing it to create data about them, and providing information about new service offerings back to the customer, after which the loop is repeated. [8] In Product Service Systems (PSS) multiple of such information feedback loops are regularly opened amongst the stakeholders in a whole PSS network, as the PSS are seldom provided by an individual company.

The rise of PSS themselves can be seen as one of the main sources of information for these feedback loops. Digitalized products are those, which have seven material properties: programmability, addressability, sensibility, memorability, communicability, traceability, and associability [9]. This enables loosely coupling devices, networks, services, and contents – the four layers of a digital service architecture. Concepts for "digitalized" products are often referred to as smart or intelligent products. These are physical products which are extended beyond their traditional use, by enabling them to act in an intelligent manner. McFarlane et al. define the Intelligent Product as "a physical and information-based representation of an item [...] which possesses a unique identification, is capable of communicating effectively with its environment, can retain or store data about itself, deploys a language to display its features, production requirements, etc., and is capable of participating in or making decisions relevant to its own destiny." [10] Intelligent product may have intelligence ranging from simple data processing to complex