Using Spatial Context Information for the Optimization of Manufacturing Processes in an Exemplary Maintenance Scenario

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Abstract: Currently, processes in the domain of plant maintenance and machine overhaul are often not transparent and inefficient in their execution. A major share of the overall maintenance time must be dedicated for locating damaged field devices, their explicit identification and time consuming search for additional device-related information such as data sheets and instruction manuals. Based on an application scenario in the *SmartFactory*^{KL}, the paper presents how spatial context information can contribute to the optimization of maintenance processes by allowing a faster location of defective field devices within plant infrastructure. As proof of concept, a navigation application is implemented. Based on a wearable computer platform, this application supports maintenance staff with seamless navigation capabilities in order to provide precise guidance to the location where a failure occurred. Furthermore, the paper generally discusses the benefit spatial context information can have for other factory processes with characteristics similar to those of processes in the maintenance domain. In addition to that, future challenges regarding the use of spatial context information in industrial applications and their integration in automation systems are discussed.

Keywords: industrial location-based services, maintenance, location technology, seamless navigation, efficiency enhancement, flexible manufacturing systems, manufacturing processes

1. INTRODUCTION AND MOTIVATION

Processes for maintaining industrial goods contribute significantly to the operational availability of a company's production infrastructure (Komonen, 2002). As such processes are highly relevant to a profitable factory operation, they have been the target of many optimization attempts in the past (Mobley, 2004). Especially in case of failure-triggered maintenance, a process optimization is highly beneficial for plant operators, as downtimes involve high cost and even short delays in fixing the problem can result in heavy losses regarding productivity (Tu, 2001). The processes of fast location, unambiguous identification and efficient repair of improperly working field devices is characterized by a comparatively small degree of automation and requires a considerable amount of domain-specific knowledge (which is often held by only a few experienced people in a company) (Levery, 2001). These processes often lack transparency and suffer from media breaks and inefficiencies. In addition to that, maintenance, repair and overhaul (MRO) work is often subject of subcontracting to external service providers (Levery, 2001). Those companies have even less knowledge about local conditions and a specific working situation on site (e.g. installation situation of a field device).

In order to meet upcoming requirements regarding efficiency and better resource management it can be anticipated that the pressure for optimizing such processes will increase in the future. A promising chance to optimize processes and workflows is offered by the use and integration of context information. Using spatial context information (e.g. actual location of a resource, current arrangement of production machinery) to precisely characterize a current situation allows for supporting ongoing work with additional, situation-related information which will aid in a faster and more efficient processing of tasks.

Focusing on a maintenance use case, this paper shows how spatial context information can contribute to increased efficiency of factory processes. Based on an application scenario, the potential for optimizing today's maintenance processes are identified. Furthermore, requirements for the use of spatial context information and their integration into the existing process are deduced. Subsequently, a navigation application is implemented and set up in the *SmartFactory*^{KL}. The paper discusses in general which kind of factory processes offer potential for optimization by integration of spatial context information and how this may lead to increased process efficiency and transparency. Challenges regarding a future use of spatial context information are highlighted under the aspects of information integration, technical dimension of location estimation and user requirements.

2. STATE OF THE ART

In order to manage MRO processes properly, a variety of software solutions known as maintenance-planning systems (MPS) are commercially available. Most of them are part of comprehensive enterprise asset management (EAM) systems, allowing for the supervision of the entire installed base of physical field devices within a production infrastructure (Miclovic, 2009). By offering a web interface to access plant maintenance data via mobile devices like smartphones and handhelds, current EAM solutions provide some basic functionality to support mobile workforces. Regarding academic research activities in the past, several projects dealt with the support of maintenance work by using context-related information (Wohlgemuth & Triebfürst, 2000; Lampe, et al., 2004). In those projects, the integration of spatial context information was mainly used to support single tasks or a dedicated phase in MRO processes. Other application domains like the logistics industry or the healthcare sector today already employ spatial context information to optimize a complete workflow or an overall process. Exemplary use cases include the successful use of indoor location information in hospitals and applications range from the management of important and cost sensitive resources (Hansen, et al., 2006; Wang, et al., 2006) to a situation-sensitive information management for doctors and nursing staff (Rodriguez, 2004).

Streamlining processes by use of spatial context information in the logistic chain is driven in research projects as well as in commercial applications. Examples are GPS-based solutions for optimised fleet management (Prakash & Kulkarin, 2003) allowing for a flexible disposition of delivery orders and adaptive route planning. Furthermore the tracking and tracing of goods on their way to the customer (Ubisense, 2009) becomes increasingly popular among logistic service providers. This enables a more precise monitoring of incoming and outgoing goods as basis for the efficient utilization of warehouse capacity as well as higher levels of transparency throughout the whole delivery process.

Building upon the use of spatial context information in the cited examples, this paper presents a solution which will lead to similar gains in process efficiency regarding the maintenance of industrial infrastructures.

3. CASE STUDY

In order to reveal the potential benefit of using spatial context information within MRO processes, an application scenario is presented. This scenario has mainly two purposes. Firstly, it gives insight into current ways of troubleshooting in production processes. Secondly, it facilitates the definition of domain-specific requirements for the integration of spatial context information into existing processes.

In the focus of this scenario lies a company running several process plants at geographically distributed sites. As a failure of a field device (e.g. a valve) occurs, the affected production line is immediately shut down. This shutdown is noticed by the responsible shop floor technician, who contacts a maintenance service contractor for immediate intervention. In addition to the error code reported by the manufacturing execution system (MES), he relays some brief information regarding the location of the defective field device (e.g. building number, ID of the production line) to the technician at the other end of the line. Searching any additional information helping to solve the problem quickly (e.g. plant layout plan, device documentations) is up to the service technician. Getting to the production site where the problem occurred is comparatively easy by using commercially available navigation devices. Starting from there, especially people who are not familiar with the production site need to start a often time consuming search for the target building based on insufficient information such as oral explanations and hints. The same holds true for precisely locating a not properly working field device within a plant infrastructure. Documentation material like wiring schemes or layout plans are only of limited help, as the real plant infrastructure already changes significantly after a short period of operation.

Having finally arrived, the field devices to be checked must be identified, which takes additional time due to imprecise documentation and dirt that has gathered on the device and its name plate. After a short and easy repair work (exchange of a valve control), production is resumed. As the downtime exceeded a certain limit, parts of the batch in production cannot be used anymore and ask for cost intensive disposal in order to meet a customer's quality requirements.

The example of this scenario reveals that a disproportional part of time in maintenance processes must be spent on locating and identifying field devices which are subject to service. As this seems to be one of the main reasons inhibiting a fast and efficient elimination of production shutdowns, the following potentials for MRO process optimization can be identified:

(1) Currently, there is no system available for supporting mobile workforce with seamless navigation functionality from a place off site down to the precise location of a defective field device within a plant infrastructure (missing existence or integration of indoor and outdoor spatial context information)

(2) Media breaks occur when error reports and codes incoming at the control room are forwarded to mobile workers (missing possibility to digitally forward error reports in combination with relevant context information)

(3) Relevant order-related data such as precise field device location, comprehensive field device documentation and detailed error reports are not allocated automatically to the service technician in charge but need to be aggregated manually.