A management tool for business process performance tracking in Smart Production

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Abstract

In this paper, we present a management tool for tracking KPIs in business processes. This tool can be used by executives from a Smart Factory in a strategic manner for defining performance targets by using Smart Production dimensions. The tool uses a standard BPMN [1] that suits the operational-driven scenarios of Smart Production.

The management tool allows attaching and tracking of KPIs to single tasks and activities of a business process modeled in BPMN. In this research work, we describe the functionality of the management tool by illustrating how it can be applied in a Smart Factory by using an Industry 4.0 use case scenario. In this use case, we describe how the management tool works within an intelligent manufacturing procedure where business processes, systems, and humans interact.

1 Introduction

There are automated tools for business process monitoring, however there is a lack of management tools that guide the process of capturing KPIs (Key Performance Indicators), in particular in Smart Production scenarios driven by Industry 4.0. Smart Production integrates business processes, humans and technologies into different manufacturing scenarios. In these scenarios we need to focus in particular tasks and activities covering following three dimensions: Humans, Systems and Machines. By taking these dimensions, we can measure the impact of them in a Smart Production process.
Therefore there is a plenty of potential for optimization of such processes. In order to optimize an important pre-step represents the monitoring and tracking of activities, tasks and actors involved. With this procedure we are able to uncover the weaknesses in process handling, perform process-driven analysis of business and production data e.g. obtained from sensors, run

[1] http://www.bpmn.org/

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benchmarking based on measurable process indicators and use past activities to drive perspective interaction with the customers.

We developed a Performance Journey Mapping Tool (PJM Tool) as a instrument that supports the business process monitoring through the visual attachment and tracking of KPIs for tasks and activities. The aim of applying the management tool is that companies can evaluate to what extent Smart Production processes are implemented and, based on that, define a strategy for increasing performance. Thus, in a use case method we will apply the PJM Tool and draw on preliminary findings.

2 Related work

In this section we introduce topics related to the purpose of this paper: business process performance tracking and Performance Journey Mapping.

2.1 Business processes and KPIs

BPMN is de facto standard for business process specification (Zor et al., 2011). The ability to support BPMN is from high relevance because the process and collaboration diagram that is created with BPMN is one of the most frequently used and therefore most important forms of business process model representations (Allweyer, 2016). Regarding Smart Production, there are modeling approaches that are extending BPMN for modeling Cyber-physical systems (Graja et al., 2016) or even implementing a whole new notation (Petrasch and Hentschke, 2016).

However, BPMN lacks the expressiveness for KPIs tracking. There are commercial tools for KPI performance monitoring but those tools are designed for setting thresholds that are monitored by a BPM engine. They do not let users set as-is and to-be values. Hence, there are only good at operational level, but not at strategic level. At strategic level we need to track and measure the change or the desire of changing. At operational level we need to focus on the results of a process execution.

Thus, the PJM Tool is a process management tool that has a wide range of applications for companies because it relies on BPMN standard and tries additionally to fill the identified missing gaps in performance tracking.

2.2 What is Performance Journey Mapping?

The principle of Performance Journey Mapping (PJM) (Höber et al., 2015) could be considered as a framework. Initially, the PJM method was developed to measure and support the service process performance for small and medium sized companies. Thus, the benefit of the PJM framework is, that it is user-oriented and easy to implement. It combines the principles and benefits of Balanced Scorecard (BSC) (Kaplan and Norton, 1996) and Service Blueprint (Bitner et al., 2008).

Usual procedure in applying Performance Journey Mapping is based on the sequence of activities (or sub-processes) in the form of a Service Blueprint (in our case a BPMN model). The first step is to identify which key figures are already determined by the respective company in this context. For this purpose, the activities and sub-processes are examined individually. In this step the method tries to identify which stakeholders are affected and what KPIs are already collected by them or others. The identified KPIs are recorded, assigned to the dimensions of the Balanced Scorecard and visualized. The first measurement gaps in the process as well as a possible imbalance in the BSC are already visible here. Both circumstances were discussed in detail in a second step. In the course of an open brainstorming, it is first possible to discuss and cover more global needs (which can not be assigned to individual gaps). Then, using the prepared performance index (consisting from previously identified and assigned KPIs), you can search for performance indicators that close the measurement gaps in a targeted manner. Finally, in the last step target values for all KPIs are to be defined.

3 Methodology

Enabling the business process performance tracking in Smart Production through application of PJM Tool requires beside the appropriate modeling also identification of relevant: dimensions, goals and relevant KPIs. For this reason we set specific dimensions in Industry 4.0 rather than using the typical dimensions of the Balance Scorecard.

3.1 Dimensions, KPIs and goals identification

We analyzed the literature on Smart Production, in particular we searched the term ”Smart Factory” in Google Scholar. By looking the definitions of a Smart Factory, we are able to understand the desired Smart Production process in the context of Industry 4.0.
The collected definitions were dissected and classified into three dimensions: **Humans**, **Machines** and **Systems**. We describe each dimension as follows:

- The **Human dimension** is related with activities performed by workers of a Smart Factory or activities performed by customers or contractors of a Smart Factory.
- The **Machines dimension** is related with the machines of a Smart Production process.
- The **Systems dimension** is related with the software components of a Smart Production process.

The outcome of the dissection and classification process resulted in a list of key attributes (refer table 3.1). Those key attributes were converted into key performance indicators (KPIs) by adding a measuring attribute such as ”number of” or ”availability”. The ”number of” measuring attribute receives an integer value and the availability measuring attribute receives a binary value of zero or one. The value is zero if this KPI is not implemented in the production process and the value of the KPI is one when it is implemented. These binary values are helpful for transitioning from a traditional manufacturing process towards a Smart Manufacturing process. The converted KPIs are to be interpreted as follows:

Goal	Dimension	KPI	Values
Context-awareness (Lucke et al., 2008)	Machine	amount of sensors	int
Context-awareness (Lucke et al., 2008)	Machine	sensor availability	0 or 1
Virtual representation (Lee, 2015)	Machine	amount of virtual representations	int
Virtual representation (Lee, 2015)	Human	digital design	0 or 1
Demand-orientation (Lom et al., 2016)	systems	personalization availability	0 or 1

Table 1: KPIs in Smart Production.

- The **sensor availability** reflects the overall potential of the production process digitalisation and automation. The availability of sensors is required for the implementation of a cyber-physical production systems.
- The **amount of sensors** represents the number of sensors that serve as potential digital interfaces for a Smart Production process. The higher the number the better is the automation potential due an increased fidelity of the physical production process with a digital one.
- The **amount of virtual representations** tells us how many different variants are supported by the process.
- The **digital design** tells us whether the humans can influence production planning process or some part of it.
- The **personalization availability** tells us whether the process or some part of it is compatible with customization.

3.2 Selection of use case

In order to test the identified goals, KPIs and dimensions presented in table 3.1 we have chosen a manufacturing process from the car industry previously introduced by (Roller and Engesser, 2014) presented in figure 1 that represents a very generic use case for variant production of cars. This use case is appropriate since all identified KPIs can be demonstratively assigned to the specific process tasks.

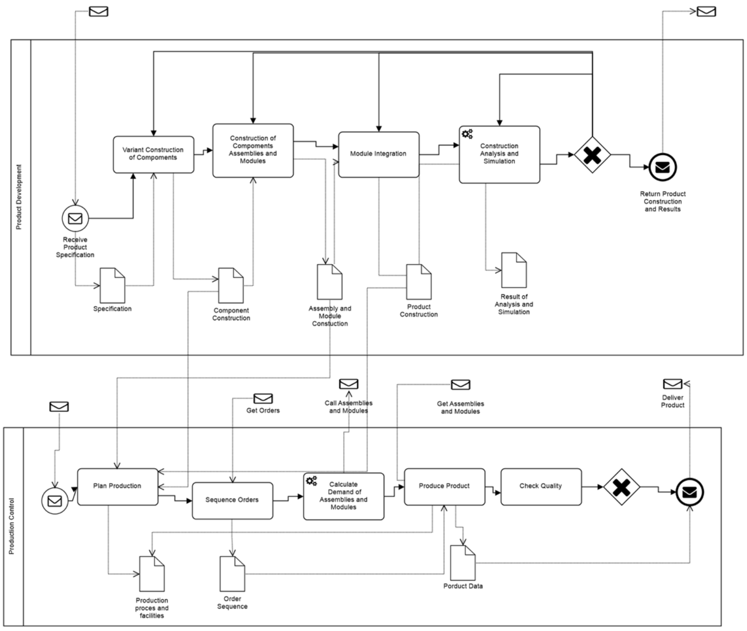


Figure 1: Production use case taken from (Roller and Engesser, 2014).

4 Results

In this section we present how the PJM Tool supports the business process monitoring using the Performance Journey Mapping framework, goals, dimensions and KPIs defined in section 3 and applied to the use case we introduced in the same section.
Once the process is modeled and available in BPMN we can load it into PJM Tool. First step requires initial definitions of the actors and goals, dimensions and KPIs we defined in table 3.1. Figure 2 shows this work flow. Next step allows us already the direct assignment of tracking entries to the task of our choice (see figure 3).
By clicking in the tree view or by direct selection in the process model we can swiftly get an overview about already defined KPIs for a specific task and edit or delete them as shown in figure 4. In this way it is possible to continuously update the status of KPIs using the PJM Tool along the production process.
To get an overview over all defined KPIs and their values, PJM Tool supports listing of them within the application as Performance Index (see figure 5) but also as an export option (e.g. as comma separated values).
The exported values can be used for instance for visual overview and tracking in other software tools as depicted in example in figure 6.

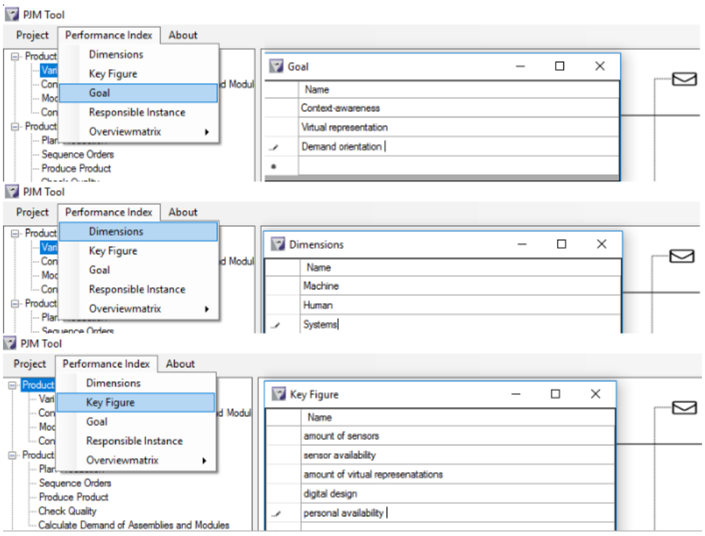


Figure 2: Definition of goals, dimensions and KPIs in PJM Tool.

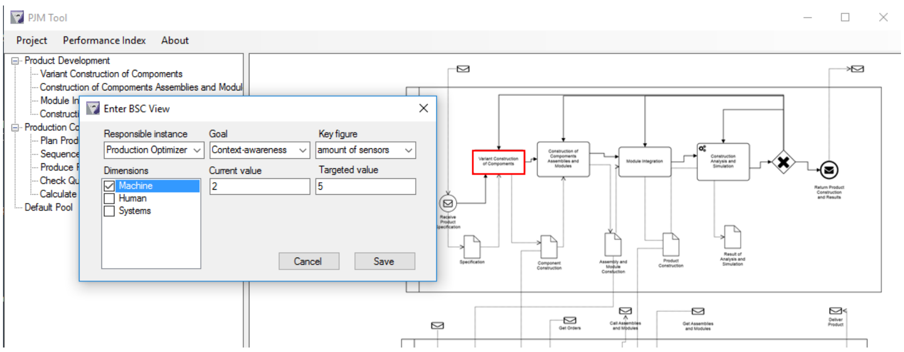


Figure 3: Entering a single KPI for a specific task in process.

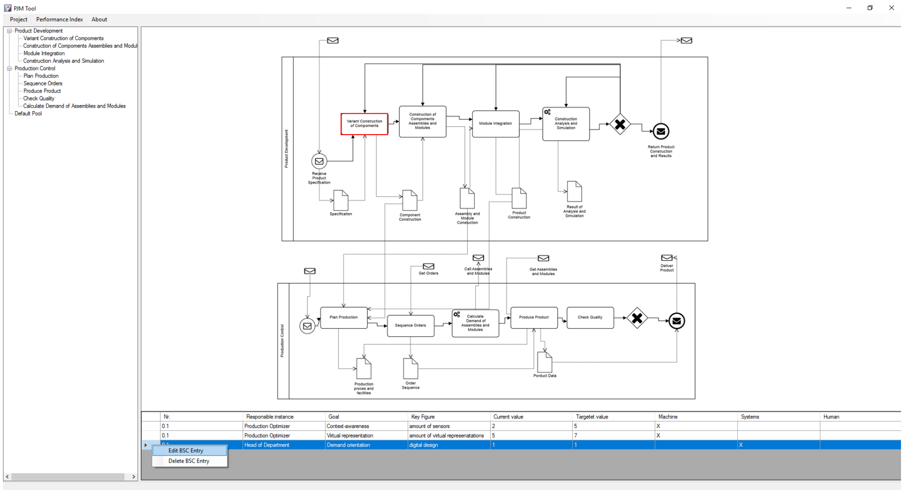
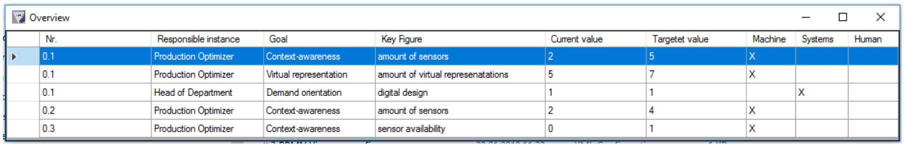
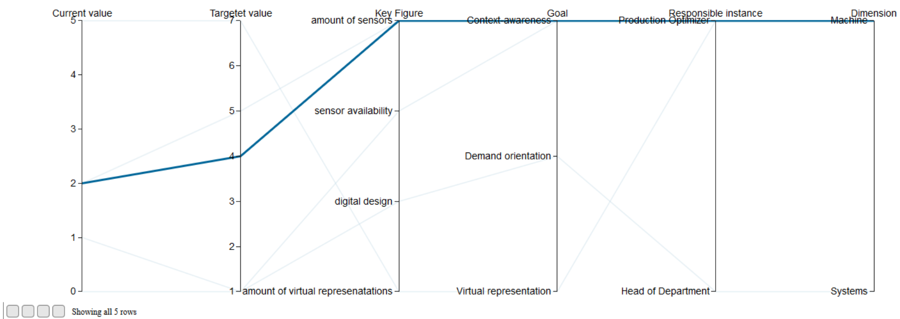


Figure 4: *Overview of KPIs in a single task.*



Nr.	Responsible instance	Goal	Key Figure	Current value	Targetet value	Machine	Systems	Human
0.1	Production Optimizer	Context-awareness	amount of sensors	2	5	X		
0.1	Production Optimizer	Virtual representation	amount of virtual represenatations	5	7	X		
0.1	Head of Department	Demand orientation	digital design	1	1		X	
0.2	Production Optimizer	Context-awareness	amount of sensors	2	4	X		
0.3	Production Optimizer	Context-awareness	sensor availability	0	1	X		

Figure 5: *Performance Index overview with all assigned KPIs in the process.*



Responsible instance	Goal	Key Figure	Current ...	Targetet...	Dimension	id
Production Optimizer	Context-awareness	amount of sensors	2	5	Machine	0
Production Optimizer	Virtual representation	amount of virtual represe...	5	7	Machine	1
Head of Department	Demand orientation	digital design	1	1	Systems	2
Production Optimizer	**Context-awareness**	**amount of sensors**	**2**	**4**	**Machine**	**3**
Production Optimizer	Context-awareness	sensor availability	0	1	Machine	4

Figure 6: *Performance Index overview with parallel coordinates visualization.*

5 Conclusion and outlook

Our novel approach combines KPIs tracking with Smart Production. This tool let users to track the change of KPIs from a as-is scenario to a desired to-be scenario. This comparison could help traditional production companies that are shifting towards Smart Production. As future work, we would like to implement an historical KPI performance analysis to be able to compare the the prior values of KPIs and to detect some trends or patterns as well as to use the historical data as base input for predictions that allows us a pro-active optimization of processes.

Credits

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