PROCESS PERFORMANCE TRACKING FOR SMART PRODUCTION

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ABSTRACT:

In this research contribution we have introduced a management tool for tracking Key performance Indicators (KPIs) in production processes. This tool can be used by executives or persosns responsible for process management of a Smart Factory in a strategic manner, for defining performance targets by using Smart Production dimensions. The presented management tool allows attaching and tracking of KPIs to single tasks and activities of a business / manufacturing process modeled in Business Process Model and Notation (BPNM). In this research work, we have described 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. Through a simple use case, we have shown that our management tool suits well for tracking of performance in intelligent manufacturing procedures where business processes, systems, and humans interact with each other.

1. INTRODUCTION

Although there are automated tools for business process monitoring, there is a lack of management tools that guide the process of capturing KPIs (Key Performance Indicators). In particular, this gap was noticable 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 encounter tasks and activities covering following three dimensions: Humans, Systems and Machines. By taking those dimensions into account, we can observe their impact and relevance for a Smart Production process. Therefore, there is a plenty of potential for optimization of such processes. In order to optimize such processes, 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. Further, we can perform process-driven analysis of business and production data e.g. obtained from sensors. Based on such insights allows us to run benchmarking based on measurable process indicators and use past activities to drive perspective interaction with the customers. For this purpose, we developed a management tool. The developed tool serves as instrument that supports the business process/manufaturing 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 or increasing performance. Thus, in order to demonstrate the usefullness of our software we will apply the tool on a generalized production scenario from literature and draw some preliminary findings from our experiment.

2. RELATED WORK

BPMN is de facto standard for business process specification [1]. The ability to support BPMN is from high relevance for process monitoring applications. The process and collaboration diagram that was created with BPMN is one of the most frequently used and therefore most important forms of business process model representations [2]. Regarding Smart Production, there are modeling approaches that are extending BPMN for modeling Cyber-physical systems [3] or even implementing a whole new notation [4]. 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 Business Process Modelling (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, there is a need for tracking and measuring the change or the desire of changing. At operational level, the focus lies on the results of a process execution. Thus, implemented process management tool that offers 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. METODOLOGY

The first step of applied methodology foresees the identification of key figures which were 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 (BSC) [6] 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.

Enabling the business process performance tracking in Smart Production through application of Proposed management KPI tracking 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.

2.1. 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 **Humans 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 (Table 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.

Table 1: KPIs in Smart Production

Goal	Dimension	KPI	Values
Context-awareness [7]	Machine	amount of sensors	integer
Context-awareness [7]	Machine	sensoravailibility	0 or 1
Virtual representation [8]	Machine	amount of virtual representations	integer
Virtual representation [8]	Human	digital design	0 or 1
Demand-orientation [9]	System	Personalization availability	0 or 1

The converted KPIs are to be interpreted as follows:

- 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.

2.2. Selection of the use case

In order to test the identified goals, KPIs and dimensions presented in Table 1 we have chosen a manufacturing process from the car industry previously introduced by [5] 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.

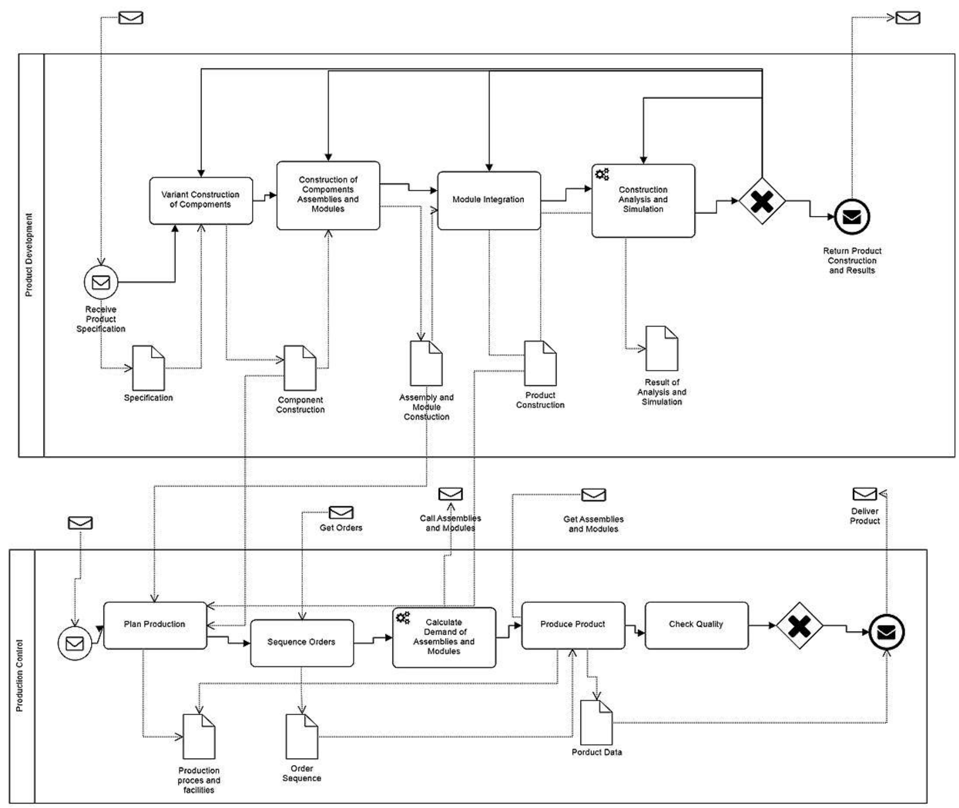


Figure 1: Production use case taken from [5] (variant production of cars).

3. RESULTS

Once the process is modeled and available in BPMN we can load it into management tool. First step requires initial definitions of the actors and goals, dimensions and KPIs we defined in Table 1. Figure 2 shows this work flow and the direct assignment of tracking entries to the tasks in the process. 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. 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 3) but also as an export option (e.g. as comma separated values).

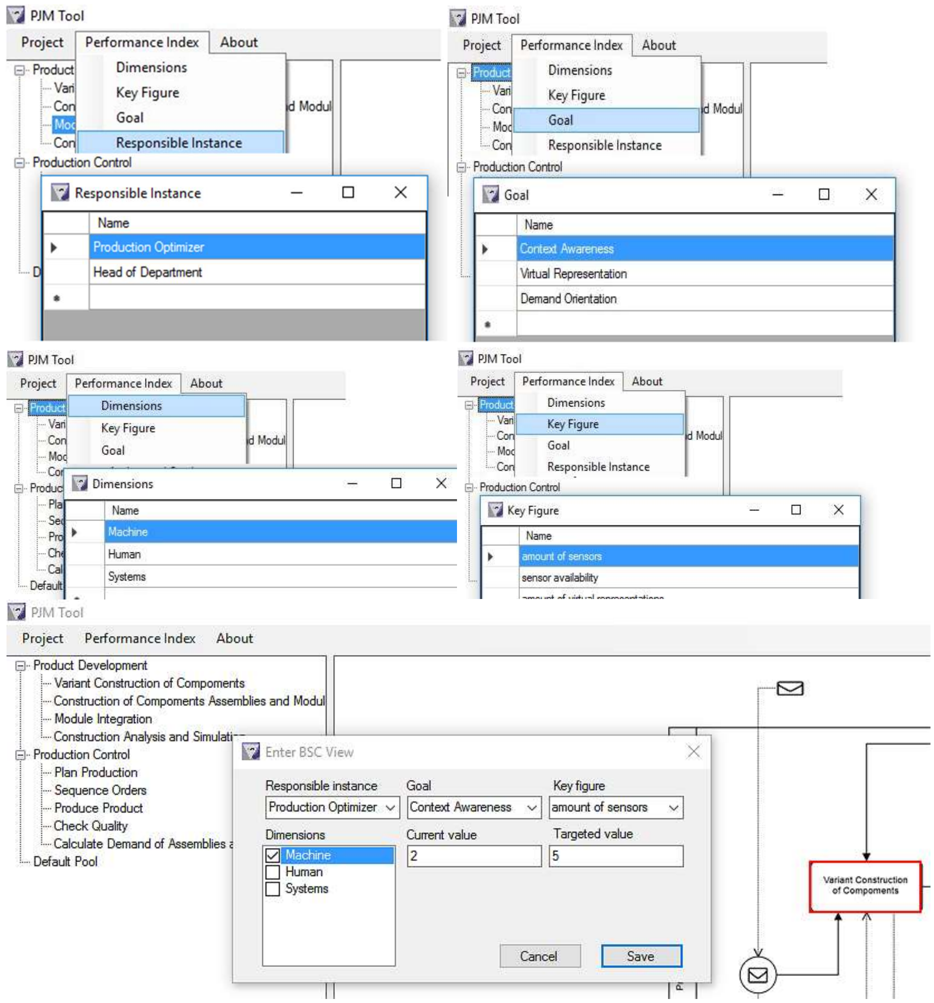
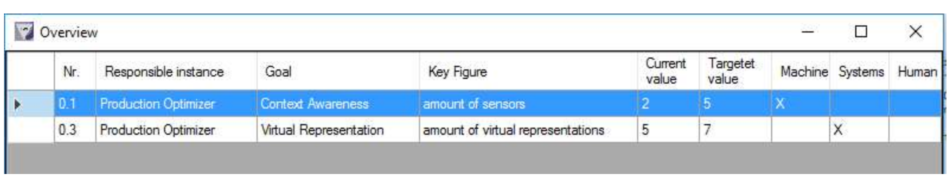


Figure 2: Definition and assignment of KPIs .


Overview

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		
0.3	Production Optimizer	Virtual Representation	amount of virtual representations	5	7		X	

Figure 3: Performance Index overview with all assigned KPIs in the process.

4. CONCLUSION

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 is the crucial contribution of presented tool. This comparison could help traditional production companies that are shifting towards Smart Production to test possible process setups and define the indicators that should be considered. 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.

5. REFERENCES

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