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Conference Paper

A New Product Driven System Concept for the Replenishment Process

Provided in Cooperation with:

Hamburg University of Technology (TUHH), Institute of Business Logistics and General Management

Suggested Citation: Alfathi, Najlae; Lyhyaoui, Abdelouahid; Sedqui, Abdelfettah (2015) : A New Product Driven System Concept for the Replenishment Process, In: Blecker, Thorsten Kersten, Wolfgang Ringle, Christian M. (Ed.): Operational Excellence in Logistics and Supply Chains: Optimization Methods, Data-driven Approaches and Security Insights. Proceedings of the Hamburg International Conference of Logistics (HICL), Vol. 22, ISBN 978-3-7375-4058-2, epubli GmbH, Berlin, pp. 55-71

This Version is available at:

<https://hdl.handle.net/10419/209281>

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Najlae Alfathi, Abdelouahid Lyhyaoui and Abdelfettah Sedqui

The product driven system improves the reactivity and flexibility of production systems. However, these requirements cannot be achieved without an availability of quality and quantity of raw materials; as a result, the optimization of raw material replenishment system is essential.

We present in this paper, the use of product driven system concept for the replenishment process.

The integration of infotronic technology makes the product smart and able to communicate with its environment, so the product "being smart" decides the appropriate time for its replenishment.

The modeling of this proposal is performed by the Business Process Model Notation "BPMN", having regard to the capacity of this tool to model at the same time, the process of making decision of replenishment by product and the treatment, and the follow-up of the order by the procurement department, as well as the exchange of information between the two collaborators, product and procurement department. To validate the modeling of the replenishment process, an experimental application is simulated by "*activiti modeler*": as a result the stock out rate and the overstocking are minimized.

The replenishment triggered by the product performs the role of the product driven system for the control of production.

Keywords: Product Driven System, Smart Product, Infotronic Technology, BPMN (Business Process Model and Notation)

1 Introduction

The growing competition between industrial companies and the emergence of information and communication technologies have made the appearance of mass customization concept. This concept leads to a high diversity of products and production processes, which requires reactive and flexible piloting systems to better satisfy customers and ensure the sustainability of companies.

The systems of piloting and decision-making have evolved from a centralized architecture, where all decisions are taken by the superior level of the system, to a distributed control architecture that relies on the principle of distribution of all decisions, also it consider that each inferior level has a controller which is autonomous and cooperate with all the other levels. Hence its flexibility and its relative tolerance to disturbance.

While the centralized architecture provides a robust and stable piloting, distributed architecture guarantees flexibility and responsiveness of the piloting system. The hybridization of these two approaches gave birth in 2003 (Morel, 2003) the paradigm of product driven system.

The concept of product driven system takes into account the capabilities of the product to play an active role to synchronize the exchange between various company processes. This synchronization requires knowledge of accurate data in real-time, it requires integration of infotronic technology, which is carrier of data.

After the use of this concept in projects relating to the management of the rescheduling of product (Noyel, 2015), hospital logistics (Huet, 2011), industrial processes in enterprises (Elhouazi, 2009). We propose in this paper

a replenishment system triggered by product to ensure a robust, flexible and reactive procurement system.

2 Literature Review

2.1 Product Driven System

The product driven system concept considers that the product is the main actor in decision making and the exchange of data in real time with other business processes. In the literature the researchers gave several definitions and characteristics to the concept. While authors introduced the concept as a derivative of the Holonic Manufacturing Systems (HMS), which the originality is to combine the centralized decisions on a priori means horizons to long term, with decentralized or distributed decisions made at the execution on short-term horizons (Elhouazi, 2009). Other authors in addition to the definition of the concept as a hybridization of two piloting approaches, they recalled the product capabilities, to play an active role of synchronization of exchanges between different enterprise systems (Noyel, 2012).

Of all the different definitions cited in the literature, one can define a product driven system, as a piloting architecture considering the product as an intelligent entity capable to communicate with its environment and make decisions that affect its flow.

2.2 Smart Product

The product seen like well by the production system, and as provider of information and services by the management system, ensures consistency between physical and information flows (Gouyon, 2009).

Several studies have provided definitions of this concept and have detailed these features. We find in (Cardin, 2013), and (Gouyon, 2009) the definitions of products intelligence levels, since the consideration of the product as active during production leads to impart technical intelligence capabilities to the product. These capabilities are:

1. owning a unique identifier
2. be able to communicate with its environment
3. be able to store its data
4. deploy a language to display its characteristics, its production requirements...
5. be able to provide or participate in a decision on its future.

Based on these five capacities, they are two technical product intelligence levels:

- Product with level 1 intelligence is able to communicate its state (form, composition, location, and key criteria). This level 1 is oriented to the product information's, it covers items from 1 to 3 described above;
- Product with a level of intelligence 2 is able not only to communicate its condition, but also to influence the decisions that are taken against it. This second level is oriented to the decision; it covers items 1 to 5 described above.

The Simplest structure of a smart product consists of the product itself during the manufacturing process and a base associated, such as a pallet carrying this product. It is the whole product + basic information which is the product oriented (Cardin, 2013).

In general, there is no stable definition, of the concept of product "smart / active ". So, we must define the aspects of intelligence and interaction with the environment.

2.3 Infotronic Technology

The intelligence characteristic associated with the product, to ensure a piloting by product, is feasible by integrating infotronic technology carried by the product to store and manages data.

There are several types of infotronic technology from the barcode to active RFID. These types differ in the informational functions that each technology can guarantee, which influence on the level of intelligence of the product. Several studies in the literature have conducted a comparison of the features offered by the infotronic technology. The studies of (Gaudreau, 2009) compared the informational functions that can guarantee each type of infotronic technology. They conclude that the smart sensor technology ensures at the same time identification of an element, information transport, the localization of a given element, the data acquisition, their processing and analysis and the decisions and reactions. While other studies (Thierry, 2009) presented the active RFID as a technology provides to the product a single identification and a processing capacity, localization and the decision making.

3 Replenishment Triggered by Product

We propose in this paper a driven product system at the raw material replenishment.

By integrating infotronic technology that makes the smart product capable of making it own decisions, the product triggers its supply by sending a request to the responsible of procurement. The request sent contains the amount of product to be procured and the time not to exceed.

As every procurement process, we consider three threshold of storage for each product reference. The green threshold is the maximum amount of product that must be stocked; the yellow line is the replenishment point, while the red line is the safety stock.

We present a mapping of the visual monitoring of stock status at Figure 1.

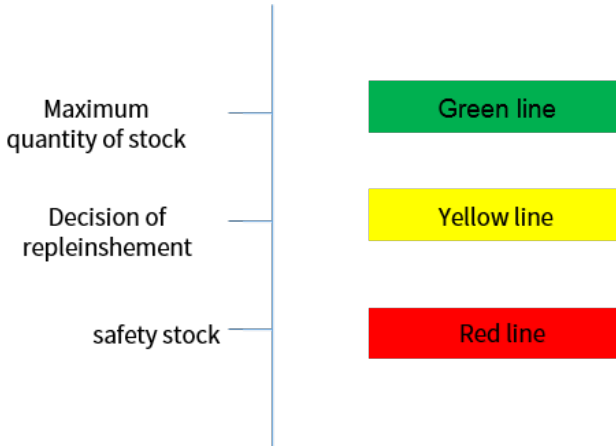


Figure 1 Storage threshold

The objective of the proposed solution is to avoid a stock out or a overstocking, thereby the monitoring of the stock state is essential.

3.1 Replenishment Stages Triggered by Product

3.1.1 Send the Request

The products on stock communicate and count each other, the moment when the quantity of remaining products in stock is equal to the yellow line, one of the smart products sends to the Smartphone, Tablet or Computer (NFC standard) of the responsible of procurement a replenishment demand including the quantity and the time not to exceed.

3.1.2 Receipt and Processing of the Request

At the receipt of the product request, the procurement department sends a command including the amount and time previously defined by the smart product.

3.1.3 End of the Deadline

At the end of this period two cases are possible:

First case: If the requested amount is received before the deadline, in which case the replenishment process started with the request of the smart product is completed

Second case: The smart product awaits the arrival of the requested amount since the red threshold is not reached.

3.1.4 Red Threshold Reached

The red threshold corresponds to the safety stock identified for each reference; this threshold is achieved because the delivery period is exceeding by the supplier. If this threshold is reached the product triggers and sends a warning to procurement responsible for the latter warns the supplier or search the requested quantity from other suppliers.

4 Modeling of the Proposal

For the system design, we present a methodology to validate the specifications set of a technological system. The figure 2 shows the steps of this process. The modeling step should be preceded by a study and selection of the most suitable tool to satisfy the criteria that the resulting model must meet.

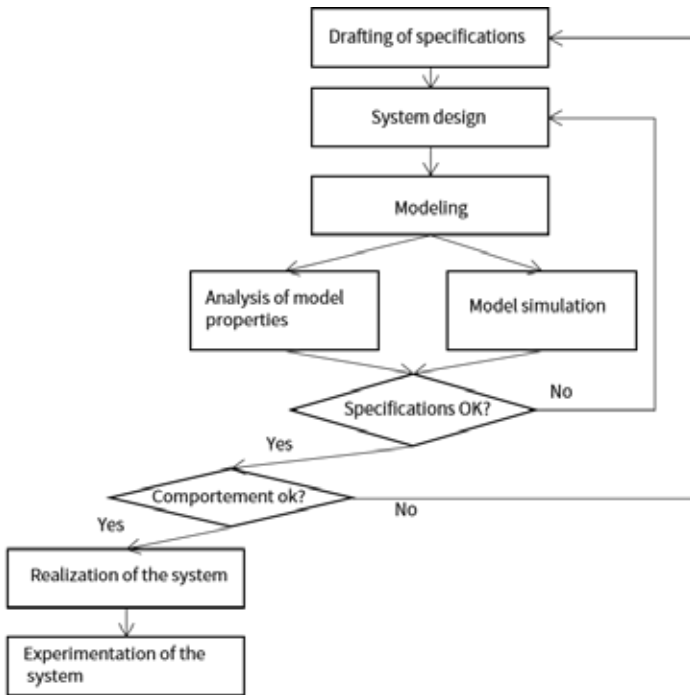


Figure 2 Method to validate process specifications

To validate our solution specifications, we have to model the interactions between the smart product and procurement department, the different flow control points, the execution of a condition or the passage from a spot to another, at end the points of synchronization between the process of requesting product by the smart product, and the treatment of the request by the procurement department.

(Verane, 2006) provides a comparison of several modeling tools according to their performance criteria. According to (Verane, 2006) the tool that meets most of these criteria and which can model the interactions between the processes is the “Business Process Model and notation” BPMN.

4.1 Business Process Model and Notation

BPMN provides a standardized representation of the process flow for business analysts, who produce the first draft, technical staff, which implements the technology solution running the process, and the business users that manage and control the processes.

BPMN 2.0 is the latest and advanced version of BPMN, thus we model according to this version. In the notation BPMN2.0 there are four categories of diagrams:

- orchestration diagram (process private and public process)
- collaboration diagram
- choreography diagram
- conversation diagram

In table 1 we present the different criteria which every type of diagram can meet.

Table 1 Criteria answered by different types of diagrams

Diagram/criteria	Description of process	interaction between process	identify the actors of process
process private	Yes	No	Yes
public process	No	Yes	No
collaboration diagram	Yes	Yes	Yes
choreography diagram	No	No	No
conversation diagram	No	Yes	No

In our case, we'll use a collaboration diagram because it allows to model:

- decision making process by the smart product,
- receiving and treatment process of the request at the procurement department.
- various data exchange and interactions between two collaborators,
- different synchronization points between the two processes.

4.2 BPMN Deployment Software

There are many BPMN modeling software, the table 2 shows some software that implement BPMN 2.0.

Table 2 BPMN Deployment Software

Software	Definition
Oryx Modeling Platform	Oryx is a web-based, extensible modeling platform, licensed under open source terms.
Activiti BPM Platform	Activiti is a light-weight workflow and Business Process Management (BPM) Platform targeted at business people, developers and system admins. Its core is a super-fast and rock-solid BPMN 2 process engine for Java. It's open-source and distributed under the Apache license.

In this paper we will use "Activiti Modeler" because of its compatibility with BPMN 2.0.

4.3 Modeling of the Proposal

After modeling our process with “Activiti Modeler”, we give the result presented in the figure 3.

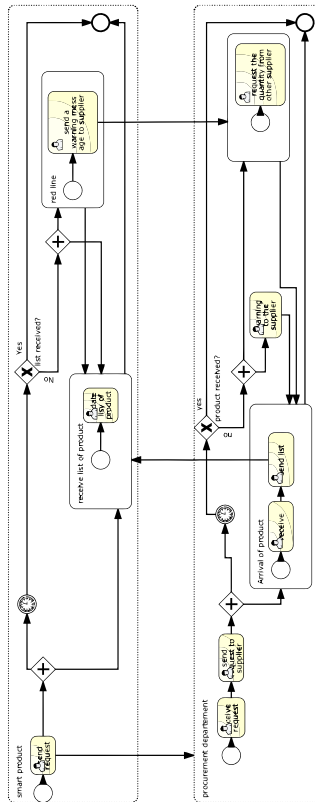


Figure 3 Modeling of new replenishment system performed by Ac

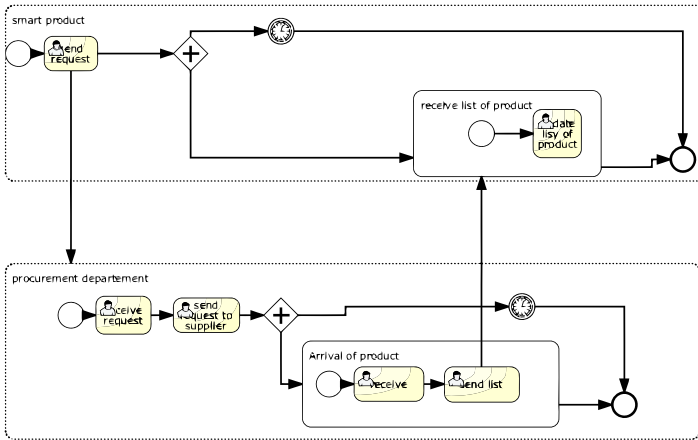


Figure 4 The model of the Case 1

To validate the proposal model, we simulate three scenarios by “Activiti Explorer”,

1. Case 1: we receive the amount requested on or before the deadline. The figure 4 presents the model of this case.
2. Case 2: we receive the products after the deadline and before reaching the red line. We find in the figure 5 the modeling of the second case.
3. Case 3: we reach the red line before the arrival of the requested products. In this case the model presented in the Figure 1 is the executed model.

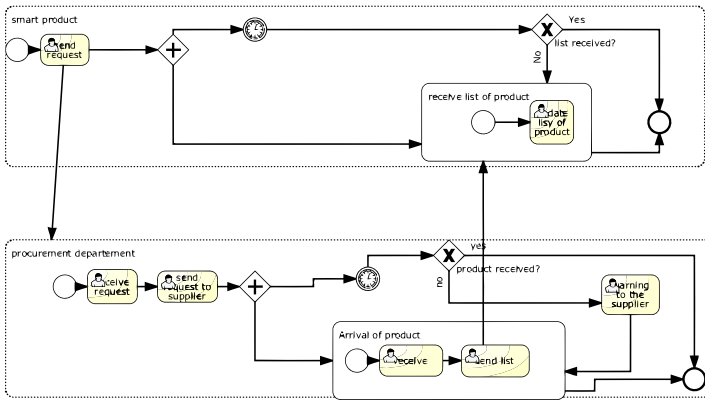


Figure 5 The model of the second case

4.4 Results

4.4.1 A Proactive and Reactive Procurement Process

The decision making of procurement at the moment when the quantity of remaining products in stock is equal to the yellow line, make the procurement process more reactive, which reduces the possibilities of stock out to reach the red line. Thus, the proposed solution makes it possible optimization of stock out rate.

4.4.2 An Advanced Monitoring of the Quantities of Products in Stock

The smart products of each reference of product's control the outgoing quantities from the stock and the received quantities. So at any time the

product know the level of its stock and have to never exceed the red (safety stock) and green (overstocking) thresholds.

5 Conclusion

The mass customization requires a reactive and flexible piloting system. In this context we proposed an improvement of the procurement process to optimize the out stock rate and the overstocking. Therefore, increasing the reactivity and flexibility of the production piloting system. The use of the concept of product driven system for the improvement of other processes such as delivery will make the companies more intelligent and efficient.

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