

Worker-Driven Improvement of Processes in Smart Factories

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Abstract

This paper describes an approach to collaboratively improving processes in smart factories. It is based on the idea of a meta-process for continuous improvement that involves all stakeholders. The participation of human workers is seen as vital and is fostered using a set of technologies including wiki-based social software and the S-BPM approach to process management. The paper shows how these technologies have been incorporated in a tool developed in the ongoing Factories of the Future project SO-PC-Pro.

1 Introduction

As production processes become more decentralised and fine-grained through the use of cyber-physical systems, they also get more complex and more difficult to maintain and improve (Horváth and Gerritsen 2013). Decentralising not only the execution of processes but also their design and improvement is a useful approach for dealing with this challenge (Zuehlke 2010). It requires all stakeholders to be involved in the re-design of smart factory processes. This includes not only automation engineers and IT specialists but also those with the most intimate knowledge about the day-to-day operations on the shopfloor: the workers.

Workers, as they can be considered domain experts in their field of activity, pose a valuable source for improvement ideas (Setiawan et al. 2011; Fairbank 2001). Nevertheless, they are often not involved in the innovation process (Setiawan et al. 2011; Fairbank 2001). The idea of employee participation in innovation processes is nothing new. Since the late 18th century employee suggestion systems (ESS) provide means for employee engagement and have been used to collect suggestions and ideas for improvements (Fairbank 2001). Integrating employees in the innovation process has the potential to lead to important improvements and financial benefits (Fairbank 2001). Empowering employees to take part in innovation and

improvement processes requires organizational structures facilitating employee involvement as well as adequate tools supporting employee commitment (Fairbank 2001).

This paper addresses the issue of collaborative improvement of smart factory processes based on tools developed in the ongoing Factories of the Future project SO-PC-Pro. Section 2 introduces the fundamental approach using a meta-process for collaborative process improvement. Section 3 presents a tool developed to support this approach. Section 4 concludes the paper.

2 A Meta-Process for Process Improvement

Most work on smart factories concentrates on processes and technologies supporting the effective interaction among production resources, including cyber-physical systems and human workers. These interactions form the core processes of smart factories. In this paper we propose to augment this *core process* perspective with an orthogonal one: a *meta* perspective dealing with the process of improving the core process, as shown in Fig. 1. The meta-process resembles a typical continuous improvement scenario, where workers identify and raise issues in the current process and make suggestions for process improvement. The issues and suggestions are then discussed among their peers, evaluated by decision makers and finally taken as a basis for re-designing the core process. Workers play a crucial role in this meta-process, as they are often the first to identify issues on the shopfloor and come up with potential fixes. The approach taken in SO-PC-Pro supports the workers' role in the meta-process in several ways:

- *Social software*: is used for sharing potential issues and suggestions for improvement with peer workers and managers. The software is based on wiki technology and has a simple user interface so that workers with almost no IT skills can use it.
- *Formal workflow for process improvement*: provides transparency and traceability of the meta-process. Workers can see that their inputs to the meta-process are taken seriously, as the workflow (the way it is defined in a use case implemented in a production company) forces production managers and engineers to provide them with feedback about these inputs.
- *Intuitive representation of the core process*: is needed for workers to exactly pinpoint the location of their issue or suggestion in the core process. The S-BPM approach (Fleischmann et al. 2012) is used for this purpose, as it isolates those parts of a process that are relevant to the specific worker. In addition, it represents processes using a very simple notation that can be learned by novice users within minutes.

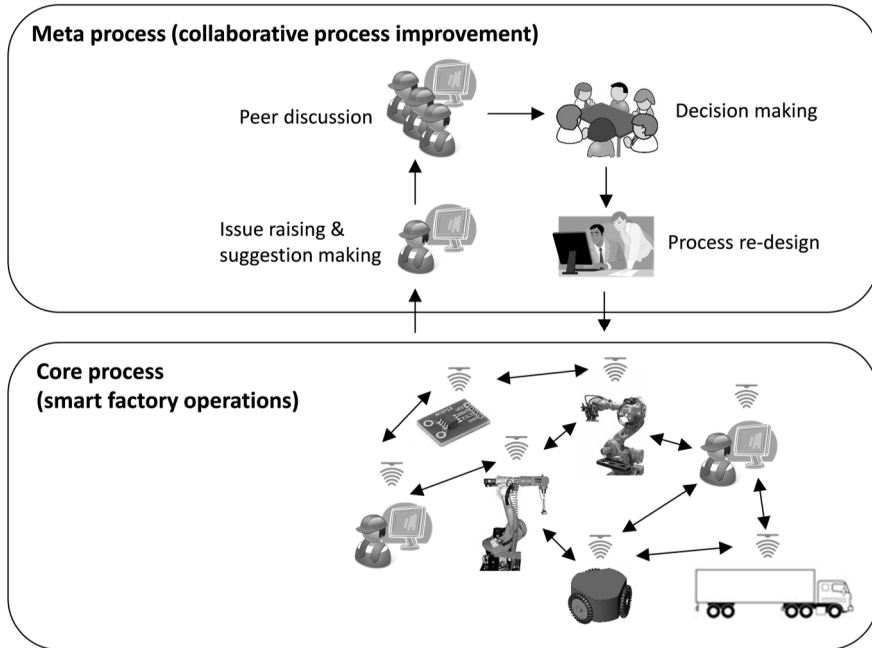


Figure 1: A meta process for collaborative improvement of core processes in smart factories

3 Architecture and Tool Support

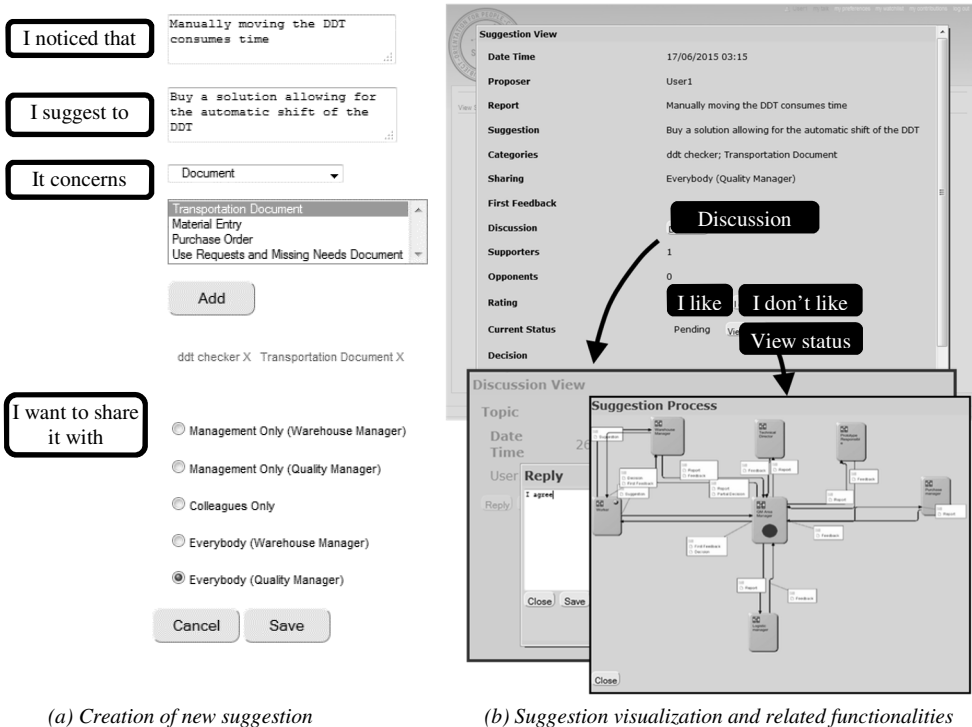
SURF (Subject-oriented *s*Uggestions for *R*e-design of *F*actory workplaces) provides a collaborative, user-friendly environment enabling workers to report and discuss issues and possible solutions in a context-sensitive way. The context-sensitive collection of issues and suggestions allows the provision of re-design relevant information within a subject-oriented process editor. *SURF* also comprises a workflow engine that enables transparent decision-making processes for workers and managers through defined, organisation-specific process representations.

SURF comprises three main modules: *Suggestion management and discussion*, *S-BPM workflow engine*, and *re-design*. While the first two modules aim at involving workers in the active, context-sensitive report of issues and suggestions for (core) process improvement, the latter focuses on supporting managers and engineers in the formal re-design of the process.

Suggestion management and discussion: This module concerns enabling users with no IT background to report issues and suggestions, as well as to discuss and share opinions about proposed suggestions or other topics, through simple user interfaces. *SURF* offers workers the possibility:

- to create and update issue and suggestion reports (see Fig. 2a – *I noticed that & I suggest to*), and relate them to a category (see Fig. 2a – *It concerns*),

- to choose whether and when to share reports with colleagues and/or managers (see Fig. 2a),
- to visualize the current state of their suggestion (*pending*, *approved* or *rejected*) as well as the current stage in the process of suggestion handling (see Fig. 2b – current stage is marked by the dot in the process model),
- to discuss suggestions with colleagues (see Fig. 2b – *Discussion*)
- to vote for or against suggestions (see Fig. 2b – *I like / I don't like* buttons)



(a) Creation of new suggestion

(b) Suggestion visualization and related functionalities

Figure 2: Suggestion creation and visualization for workers

S-BPM workflow engine module: This module implements the execution of the meta-process. When running an organisation-specific S-BPM *process improvement process*, it enables managers and decision makers to handle workers' suggestions in a collaborative and structured way. They are provided with a specialised user interface (not shown due to space limitations) with which they can set the status of a suggestion to *approved* or *rejected*, and textually describe their decision together with a justification (rationale). This information is then provided as feedback to the workers. When giving feedback, decision makers have the option to use a *localization analysis* feature to determine the workers potentially affected by a suggestion.

Re-design module: This module offers an S-BPM process modelling editor enhanced with re-design support (Fig. 3). Depending on the selected element in the S-BPM diagram of the core

process, the editor provides designers in the *Worker Issues* tab a list of related issues and suggestions. For instance, if the process step *Check DDT*¹ is selected in Fig. 3, the workers' input associated with this step is displayed. Specifically, the editor:

- *displays the context-sensitive suggestions made by workers* (e.g., “buying an automatic solution for moving the DDT”). Being shown the workers' issues and suggestions side by side, a process engineer has immediate access to possible solution alternatives.
- *shows the rationale for previous decisions regarding process improvement*. By representing both current and previous issues, the editor also provides access to the knowledge gained from previous improvement ideas and captured as the rationale associated with previous decisions (i.e., *Rationale* field in Fig. 3);
- *enables the ad-hoc ordering of workers' issues* to support the engineer in identifying connections among individual issues.

The *SURF* is built on top of two existing base technologies, the MoKi tool (Ghidini et al. 2012) and the Metasonic Suite (<https://www.metasonic.de/en>). A shared repository storing issues and suggestions is used for the exchange between the presented modules. Both the *suggestion management and discussion* (MoKi-based) and *S-BPM workflow engine* (Metasonic Flow) modules read and write information from/to the shared repository, while the *re-design* module (Metasonic Build) only reads suggestions for providing them to the process re-designers.

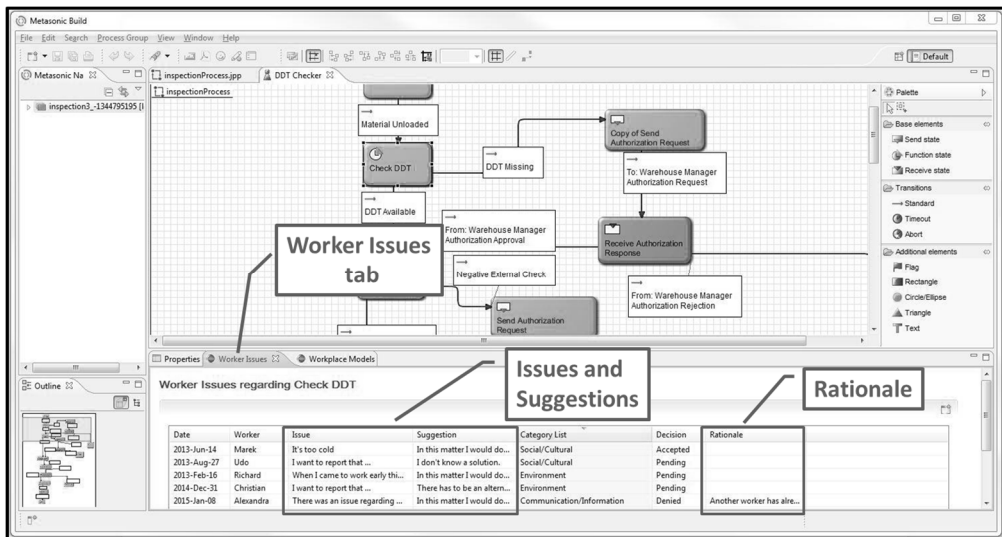


Figure 3: S-BPM editor comprising context-sensitive suggestions for improving the core process

¹ DDT is the name of a particular transportation document handled in the goods receiving process of a factory (used as a core process example).

4 Conclusion

A pilot implementation of the *SURF* tool has been installed and tested in the goods entry area of a large Italian manufacturer of industrial cleaning machines. Its objective is to increase the workers' participation in the continuous improvement of operations and workplaces. Prior to using this tool, the number of issues and suggestions reported by workers has been quite low. The company's management believes that this is due to the informal, intransparent and face-to-face nature of the former improvement process. First experiences with using the *SURF* tool are very promising in terms of a significantly increased number of issue reports and positive feedback from the users. Management is currently planning its productive use and rollout to other shopfloor departments.

At present, the company does not use any smart factory technologies. For application scenarios with automated and smart production processes, some adaptations to the tool may be required. However, the underlying approach will remain the same: (1) Implement a formal meta-process that allows all stakeholders to get involved in improvement initiatives; (2) provide simple, intuitive user interfaces, tool features and process representations to reduce the entry barrier for untrained users.

Acknowledgements

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