Available online at www.sciencedirect.com

ScienceDirect

IFAC-PapersOnLine 49-19 (2016) 420–425

Human-CPS Interaction – requirements and human-machine interaction methods for the Industry 4.0

Carsten Wittenberg

Robotics & Automation Department, Heilbronn University,
Max-Planck-Str. 39, D-74081 Heilbronn, Germany
(e-mail: carsten.wittenberg@hs-heilbronn.de)

Abstract: Cyber-Physical Systems (CPS) and ideas from the internet of things leaded to the concept of the industry 4.0. The so-called Industry 4.0 implicates techniques like cloud-computing and self-organizing machines. The degree of technological complexity increases. Beside the technological innovation the use context and the tasks for the users will also be changed. In the design phase the engineers have to handle the increased complexity. In the operating phase the operators and also the service and maintenance technicians have to keep the production systems running. This paper discusses the effects of Industry 4.0 and shows the results of the research on mobile applications for supporting service and maintenance technicians under the influence of the CPS/Smart Factories/Industry 4.0.

Keywords: Human-centered design, cyber-physical systems, user requirements, mobile systems, Industry 4.0.

1. INTRODUCTION – CYBER-PHYSICAL SYSTEMS AND INDUSTRY 4.0

The domain of industrial automation is reserved and conservative to new developments in the information technology. One reason is that industrial productions systems are built to output products for a long time. A period of 20 to 30 years is not unusual. From this it follows that the used technology and the related spare parts has to be accessible over the whole period. But – is it certain that today's information technology is still available in 30 years?

A second reason is the need for information security. Only authorized persons and institutions should have access to any sensitive data. But the modern information technology is based on (public) networks and outsourced information services. How can a company make sure that sensitive information is secure against unauthorized access e.g. from a third party or a competitor? How can a company make sure, that nobody can inflict damage with these data?

Nevertheless, new information technologies are observed and proofed, if these technologies are suitable for the producing industry. As a result, the concept of the Industry 4.0 based on cyber-physical systems, the Internet of Things (IoT) and smart factories was introduced to the public in 2013.

What represents industry 4.0? After the mechanizing with water or steam power (industry 1.0, e.g. the weaving loom), the mass production with band conveyors (industry 2.0, e.g. Henry Ford's car production) and the use of electronics (industry 3.0, e.g. the programmable logic controller PLC) the level 4.0 is now reached (Fig. 1). Some elements were taken from the Internet of Things and the ubiquitous computing (Weiser, 1991), some from the big data subject or the service architecture topic to shape the concept of the smart factory (Bauernhansl et al., 2014).

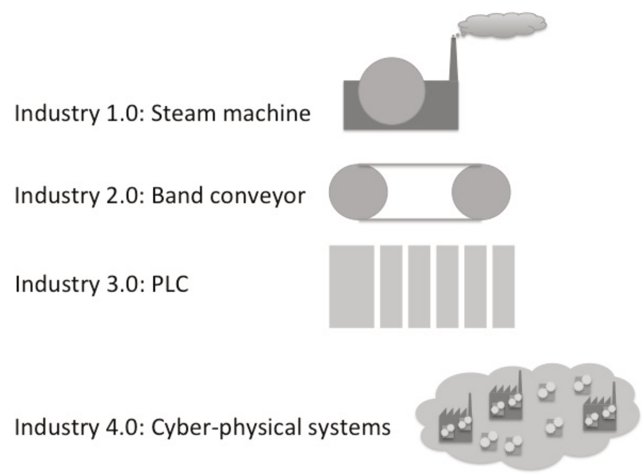

Fig. 1. From Industry 1.0 to Industry 4.0 (Wittenberg, 2015)

1.1 The smart factory based on cyber-physical systems – the vision of industry 4.0

But what is the vision of Industry 4.0? What is a smart factory? The elements in a production plant become so-called cyber-physical devices that have an increased intelligence and ability to communicate with themselves compared to today's machines. With these abilities the cyber-physical systems can take a part of the planning and dispositive tasks. The machines take care about adequate supply of material, change production method to the optimal one for actual product, or figure out a new method by itself (catchword self-learning machine). The machines get social characteristics and build their own "social" networks (figure 2).

10.1016/j.ifacol.2016.10.602

As one result the classical automation pyramid is change. The machines – typical located at level one (field level) – get functionalities from the upper levels, particularly from the levels 3 (Manufacturing Execution System MES/plant management level) and level 4 (Enterprise Resource Planning ERP/enterprise level). Also new topics like the service-based architecture influence the systems.

At first sight it might seem that the load for the users is clearly reduced. But is this true?

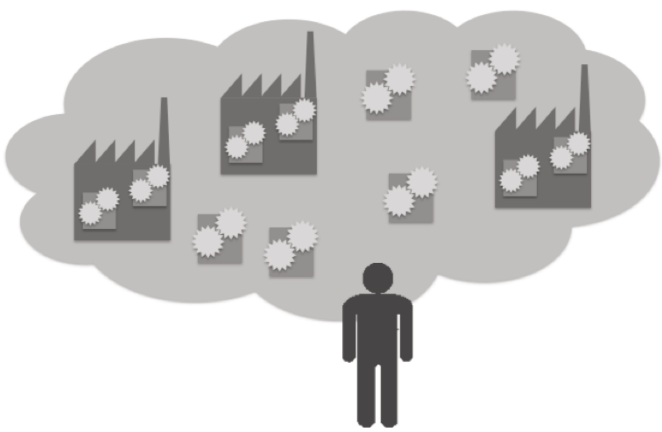

Fig. 2. Cyber-physical systems with their own "social" network? (Wittenberg, 2015)

1.2 The lifecycle of automated production systems

In the lifecycle of industrial automation systems (figure 3) two phases with three user groups can be pointed out:

1. During the engineering phase the user group of system designer develop and design the whole production system. Consecutively different craft groups (e.g. mechanical engineers, electrical engineers, PLC software engineers etc.) work with their specific software tools on the designing, configuring and building up the production systems.
2. During the operating phase two user groups play an important role:
    a. The operators supervise and control the assigned production line.
    b. The service and maintenance technicians keep the production ticking over.
3. The last phase "scrapping" is from the industry 4.0 point of view not that important.

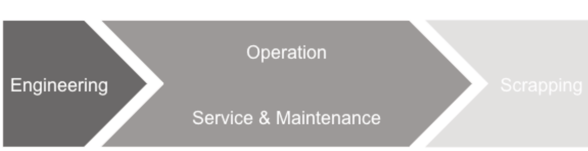

Fig. 3. Lifecycle of automated production systems

What are the impacts of industry 4.0 for the user and for their software tools? Apparently the complexity of the procedures inside the automated productions systems is extremely raised. Beside this also economic issues and functions (based on the integration of level 3 and 4 functionalities, see above) have to be considered by the designers. For example, user requirements concern issues supporting the collaboration in a mixed team of special designers. Also requirements regarding the consistent data flow through all the different engineering tools become effective again – these topics were already discussed but not solved during the work on the digital factory.

Changing the focus to the operating phase the two user-roles operator and service and maintenance technicians are also confronted with changed working conditions.

Due to the fact that the machines undertake more tasks from the operator the remaining operator's tasks get more and more an observing character. The operator has to monitor and supervise the automated production system. But the increased information and communication power of these systems lead to a complexity that is not understandable (similar to other developments like autonomous car driving etc.) by classic user interfaces used actual in the industry. The operator needs support to keep the system stable in case of a fault.

The service and maintenance technician has also an altered need for information. The cyber-physical systems will have a huge diagnostic functionality. For evaluation and interpreting this new data the technician has to be supported by new user interface concepts with site-directed information access (e.g. via mobile devices combined with techniques like AR).

2. CHANGES FOR THE USERS – NEW USER REQUIREMENTS AND WORKING CONDITIONS?

It seems clear that the entry of innovative techniques from the computer science influences the working conditions of the users. The question is in what kind of manner – and if there is a need for further support of the user.

2.1 The engineering phase in the lifecycle of automated production systems

Unlike usual products the production plants are single-unit products. As a result, the engineering and development effort play a mayor role. This can be divided in three phases: Design, manufacturing & assembly, and commissioning. In the classical way the commissioning phase in the field needs the most time.

To reduce time and effort the idea of the digital factory was developed during the last 10 years (Figure 4). Parts of the commissioning phase should be done with simulation tools. As an advantage for the user this work is relocated from the field to the office. As a disadvantage the number of tools increases.

Also in the classical approach a huge number of Computer-aided (CAx) tools are necessary for fulfilling the engineering tasks (Figure 5). A major problem for the user is that these tools are disharmonious – both in their databases and in the interaction with the user (During et al., 2001, 2002, 2006).

Typically, each tool has a different look & feel – different handling, different appearance, different menu structures, different keyboard layout, different shortcuts etc. In some