Cyber-physical system for integrated management of steel and rolling mills – architecture and implementation details

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1. Introduction

Cyber-Physical Systems (CPS) are systems of collaborating computational modules which are in intensive connection with the surrounding physical world and its on-going processes, providing and using, at the same time, data-accessing and data-processing services available on the internet [1]. In other words, these systems enables objects and processes residing in the physical world (e.g. manufacturing facility), to be tightly coupled with computing, communication and control systems in the cyber world [2]. In industrial applications the CPS systems are usually called Cyber-Physical Production Systems (CPPS) and are one of the key technical enablers of 4th industrial revolution (often referred to as Industry 4.0 [3]). In the past years tremendous amount of work was done on implementing CPPS in many branches of industry. Many concepts like holonic or agent-based systems [4,5], cloud, fog, dew, edge computing [6–8], Wireless Sensor Network [9] and many others were successfully implemented to address Industry 4.0 requirements. This Presentation is a part of the work undertaken in the project aiming to create computer system integrating management of the steel and rolling mills producing billets and long products. The main goal of the Project is to conduct R&D works aimed at development of globally innovative, integrated with the infrastructure of steelmaking facility (Electric Arc Furnace "EAF" – Ladle Furnace "LF" – Continuous Casting Machine "CCM"), hybrid IT system for optimizing and modeling steel billets production process i.e. solution significantly contributing to the quality of CMC Poland Sp. z o.o. (CMC, Company, Applicant) products by providing full control over liquid steel temperature, including superheating temperature.

2. System architecture

2.1. Dependency on other systems in company infrastructure

The proposed System (called also SWP from Polish shortcut System Wspomagania Produkcji) plays important role in IT infrastructure of the company, communicating at least three of the most important systems (Figure 1). The first one is SAP responsible for management of sales gathering data of customers, orders, dates of contracts and material indexes with tonnage of sales. The data are exported to SWP system automatically every two hours in form of external database. The records of contracts are used further for purposes of rolling campaigns planning and scheduling of the

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wok in steel mill. The plans of rolling campaigns are proposed automatically according to specific rules delivered by the rolling mill and department of sales. On the basis of each campaign as well as contract dates the System schedules casting sequences for steel mill according to metallurgical knowledge about joining of particular heats in each sequence, working calendar and rules delivered by steel plant managers.

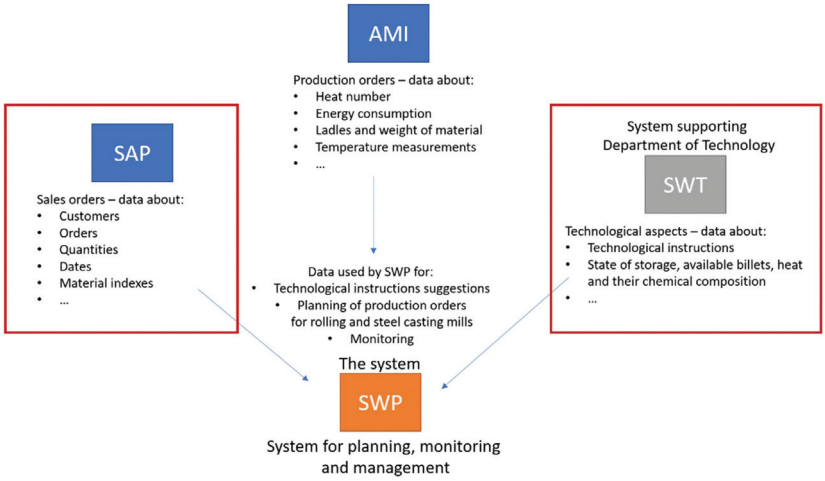

Figure 1. The proposed System in infrastructure of CMC Poland Sp. z o.o.

SWT system delivers information on technological instructions, which are crucial for chemical composition of the casted steel and all the technological issues related to the way of heat preparation and casting. These data are also important for steel plant work scheduling, but also for prediction of liquid steel cooling rate inside the main ladles, what is the most interesting between LF and CCM to maintain casting temperature regimes for each grade of steel. The information needed for such prediction is supported also by AMI system, which is responsible for gathering all the data related to production processes including static as well as time-dependent parameters of production devices. The data are copied redundantly and gathered in external database to be used also for monitoring process and support of process operator by prediction and suggestion of energy usage.

2.2. Architecture of the system based on microservices

The System was designed to be implemented on the basis of microservices architecture. Such approach allows to design and implement each module separately according to specific technical or functional requirements e.g. monitoring module is based on implementation techniques, which allow to use Artificial Intelligence procedures to analyze images captured from CCTV cameras, while on the other hand SAP communication module is implemented as a typical back-end service in C#. Additional advantage of such solution is also maintenance of the software during lifetime, which can generate problems and high costs – in this approach maintenance is divided between each module and can be done separately assuming that communication protocol and the way of information exchange through the message broker do not change. The design with selected modules is presented in Figure 2 and it will be presented in details during conference presentation.

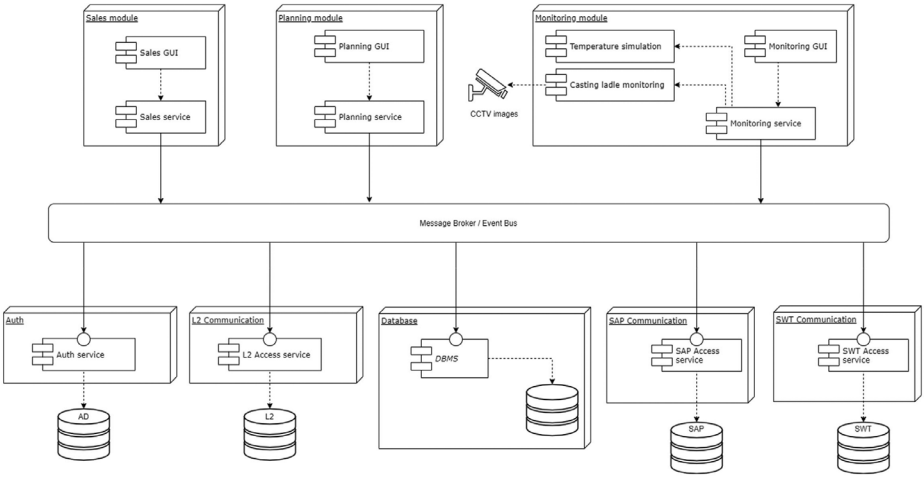

Figure 2. Architecture of the system in form of the microservices components.

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