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Letters

Modularized assembly system: A digital innovation hub for the Swedish Smart Industry

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ABSTRACT

This paper describes a novel approach to build a modular and adaptable information platform for Chalmers Smart Industry Hub. The platform utilizes the IoT paradigm i.e. decentralized and event-driven architecture, to interconnect production modules such as an assembly system, ERP, analytics, etc. Real life industrial problems are realized as industrial demonstrators that can utilize one or several production modules to exemplify specific use cases.

1. Introduction

Chalmers Smart Industry Hub (CSIH) is part of a European network of digital innovation hubs (DIHs). DIHs exists to ensure that all types of companies, no matter the size, can grasp the advantages of new digital technologies [1]. Finding the right competence regarding digital technologies and IT is crucial for the manufacturing industry that is transforming to the fourth industrial revolution [2]. CSIH is focused on complex assembly systems within the concept of Smart Industry and Cyber Physical Production Systems (CPPS) [3]. As a part of this digital hub there is a plan to implement a modularized assembly system that will be able to cope with many different types of products, flows, automation, and people. The aim of this paper is to describe how the information platform should be built to achieve adaptability and modularity between different industrial demonstrators.

2. IoT in manufacturing

The traditional structure in most manufacturing systems follows the automation pyramid, which is a highly hierarchical model where one system strictly follows the instruction of the system above [4]. Future systems need to be more horizontally integrated and decentralized with more autonomous sub-systems to cope with increased complexity and highly customized products [5]. This development is driven by the IoT paradigm that brings together physical things, Internet services, and semantics [6]. IoT systems are decentralized and heterogenous by nature. This require the architecture to be event-driven, which fits very well with the service oriented architecture (SOA) [7]. According to Al-Fuqaha et al. [8] there are many challenges with implementing IoT based systems. Some of them, like managing and adding devices, availability of services, and end-to-end interoperability, can be aided by utilizing cloud based platforms for IoT applications.

Fig. 1 visualizes the philosophy, or architecture, for CSIH. It is a modularized IoT-based assembly system. The backbone of the architecture consists of a connectivity infrastructure and an IoT Platform. The connectivity infrastructure provides fixed and mobile connectivity and cloud capabilities. IoT platform provides end-to-end interoperability for applications that require several modules to operate. The modules are visualized as jigsaws as they are easily attachable and replaceable. Three modules are fixed in on the backbone since they constitute the minimum to implement a functional assembly system. An ERP module is needed for order management, some analytics capabilities are needed to be able to measure the efficiency of the production system, and the assembly system itself that also acts as any other module. The system extension modules represent any other implementation. Note that extension modules can also extend existing modules.

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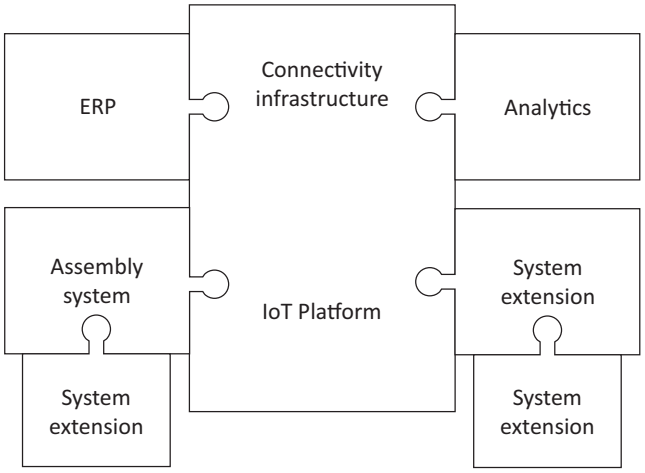

Fig. 1. Chalmers Smart Industry general architecture. The backbone consists of a connectivity infrastructure and an IoT Platform. Modules, that are different part of a manufacturing system, can be hooked on to the backbone and communicate with other modules. Modules can directly attach to other modules to create larger autonomous modules.

3. Industrial demonstrators

The industrial demonstrators are exemplified in Fig. 2. The backbone of the system is realized by the laboratory facility with Internet connectivity, cloud solution, an Ericsson LTE network with 5G enabling technologies, and PTC ThingWorx as the IoT Platform. The main assembly system consists of four assembly stations. IFS is the chosen solution for the ERP module and Axxos makes the analytics module. The remaining seven modules are the industrial demonstrators. These demonstrators do often require one or several base modules to realize any real value. The maintenance demonstrator, for example, require two base modules, assembly system and analytics, to simulate more efficient maintenance strategies. Operator wellbeing can be measured in a stand-alone scenario but it's real potential is shown in a proper assembly system. This modularized architecture becomes even more powerful when combining several industrial demonstrators in the same scenario. That becomes possible if modules are autonomous in their decision making while clear and efficient with their data sharing.

3.1. Interoperability

For future interoperability, it is important to utilize well defined and modern standards, like OPC UA, even though many equipment providers do not fully support it yet. Furthermore, it is crucial to continue to stay up to date with current standards and adapt when the landscape changes. For software systems SOA is a convenient approach, this becomes especially useful when utilizing the IoT platform as a middleware, then the service API between the platform and a certain module, e.g. MTConnect or OPC UA, can stay the same, while hardware is changed or replaced. However, service based models does not guarantee interoperability since there can still be issues with the ontologies or semantics. Higher levels of standards are applied here. In the example of the automation management system [9], which utilizes a RESTful Web Service from the Play network, is based on the AutomationML standard [10]. Finally, now when software is more common knowledge and automation is not limited to manufacturing, standards are often driven by open source communities. For this reason it is important to choose, or at least acknowledge, open platforms [11].

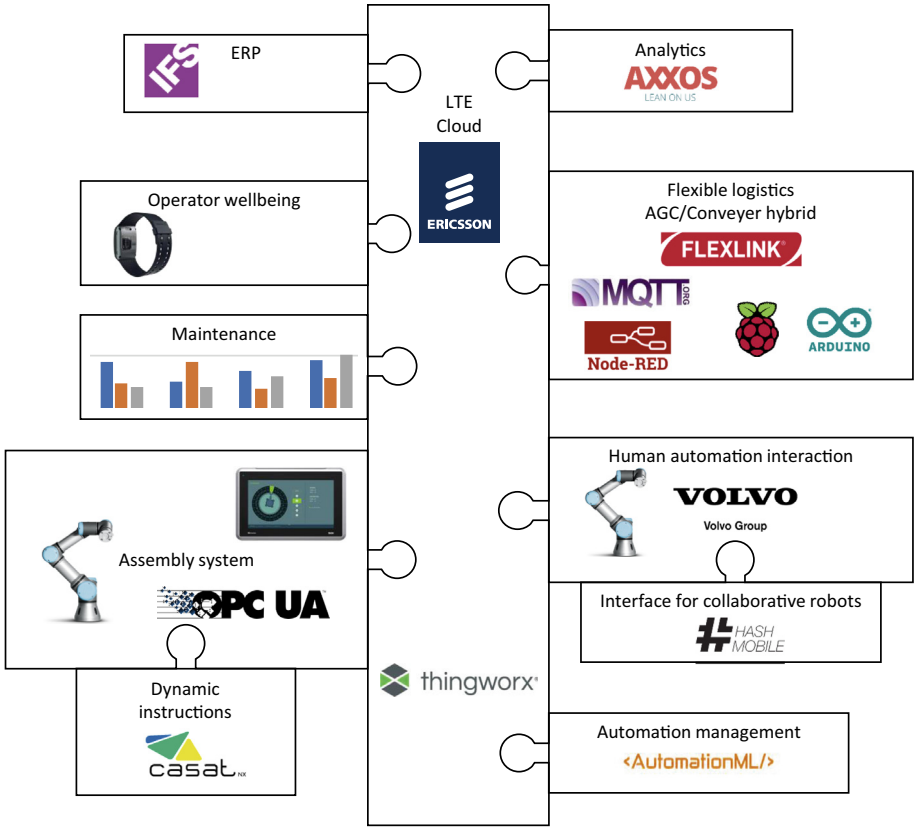

Fig. 2. Seven industrial demonstrators at Chalmers Smart Industry Hub.

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