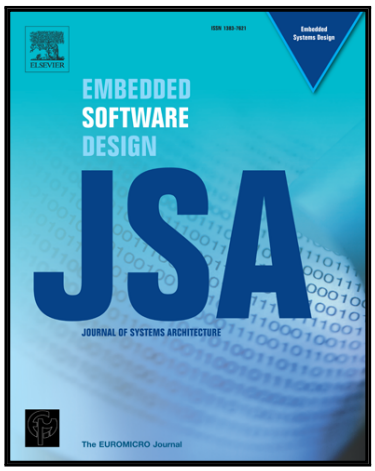

Container-based Architecture for Flexible Industrial Control Applications

Thomas Goldschmidt, Stefan Hauck-Stattelmann, Somayeh Malakuti, Sten Grüner

PII: S1383-7621(17)30498-8
DOI: 10.1016/j.sysarc.2018.03.002
Reference: SYSARC 1482

To appear in: *Journal of Systems Architecture*

Received date: 16 November 2017
Revised date: 5 February 2018
Accepted date: 3 March 2018

Please cite this article as: Thomas Goldschmidt, Stefan Hauck-Stattelmann, Somayeh Malakuti, Sten Grüner, Container-based Architecture for Flexible Industrial Control Applications, *Journal of Systems Architecture* (2018), doi: 10.1016/j.sysarc.2018.03.002

Container-based Architecture for Flexible Industrial Control Applications

Thomas Goldschmidt
ABB Digital
Ladenburg, Germany
Email: thomas.goldschmidt@de.abb.com

Stefan Hauck-Stattelmann
Rail Control Solutions
Bombardier Transportation Signal Germany GmbH
Mannheim, Germany

Somayeh Malakuti and Sten Grüner
Software Systems and Architectures
ABB Corporate Research
Ladenburg, Germany
Email: {somayeh.malakuti, sten.gruener}@de.abb.com

***Abstract*—Cyber-physical systems and the Internet-of-Things are getting more and more traction in different application areas. Boosted by initiatives such as Industrie 4.0 in Germany or the Industrial Internet Consortium in the US, they are enablers for innovation in industrial automation. To provide the advanced flexibility in production envisioned for future automation systems, Programmable Logic Controllers (PLCs), as one of their main building blocks, also need to become more flexible. However, the conservative nature of this domain prohibits changes in the controller architecture impacting the installed base. Currently there exist various approaches that evolve control architectures to the next level, but none of them address flexible function deployment at the same time with legacy support. In this paper, we present an architecture for a multi-purpose controller that is inspired by the virtualization trend in cloud systems which moves from heavyweight virtual machines to lightweight containers solutions such as LXC or Docker. Our solution includes the support for multiple PLC execution engines and adds support for the emulation of legacy engines as well. We evaluate this architecture by executing performance measurements that analyze the impact of container technologies to the real-time aspects of PLC engines.**

1. Introduction

More and more domains apply concepts such as cyber-physical systems and the Internet-of-Things to their specific environments. Especially, in the area of industrial automation this trend together with different initiatives such as Industrie 4.0 in Germany or the Industrial Internet Consortium in the US provide a nutritious ground for innovation. More flexible production and easy as well as secure access to data within factories are just two of the goals of this envisioned technological revolution. In order to provide these features also the main building blocks of these automation solutions, such as the Programmable Logic Controllers (PLCs), field devices as well as Supervisory Control and Data Acquisition (SCADA) systems need to become more flexible and self-aware regarding the functionality running on them. Thus, they evolve from traditional automation components to intelligent, reconfigurable cyber-physical systems. For example, to efficiently run production lines that can produce a high variety in products the changeover time needs to be reduced to a minimum. Among other things, this requires an efficient approach to deploy new functionality on automation components such as PLCs. Additionally, more and more complex functionality can directly be run on PLCs as they become stronger in their computational power. For example, switching functions for industrial real-time networks could be deployed on such devices in addition to its standard control functionality. Another example is to deploy software that does object recognition based on a video stream directly on the PLC. Such functions as well as information models that provide all necessary information as well as meta-data of the capabilities, current status and deployed functions will evolve PLCs towards real cyber-physical systems.

However, most companies in this domain are rather conservative and are therefore reluctant to move to new controller architectures where they are not guaranteed to keep their installed base running as is. Thus, while moving to new control architectures also support for legacy applications including migration strategies needs to be made available. While there exist various approaches that evolve control architectures to the next level [1], [2], none of them addresses flexible function deployment at the same time with legacy support. One of the main challenges for migrating legacy control code is to replicate the controller's behavior as close as possible. Just transforming control code into the code of a new controller's language is therefore often not a desirable solution [3]. The general life cycle challenges for automation systems and possible mitigation strategies are addressed by ongoing standardization activities [4], but there is no generic solution to integrate legacy control applications in new controller designs yet.

In this paper, we introduce real-world use cases that motivate why a container-based solution for industrial control is a basis for future automation system architectures. Based on these use cases, we present an architecture for a multi-purpose controller that is inspired by the virtualization trend in cloud systems which moves from heavyweight virtual machines to lightweight containers solutions such as LXC or Docker. Our solution includes the support for multiple execution engines and adds support for the emulation of legacy execution engines as well. As container-based virtualization