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Editorial

Embedded Systems Design in Intelligent Industrial Automation

Luca Ferrarini,[1] Jose L. Martinez Lastra,[2] Allan Martel,[3] Antonio Valentini,[4] and Valeriy Vyatkin[5]

[1] *Dipartimento di Elettronica e Informazione, Politecnico di Milano, Milano 20133, Italy*
[2] *Department of Production Engineering, Tampere University of Technology, 33101 Tampere, Finland*
[3] *O[3] neida Inc., 135 Dunbarton Court, Ottawa, Ontario, Canada K1K 4L6*
[4] *O[3] neida Europe, 42 rue de l'Eglise, 1150 Brussels, Belgium*
[5] *Department of Electrical and Computer Engineering, University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*

Correspondence should be addressed to Valeriy Vyatkin, v.vyatkin@auckland.ac.nz

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Industrial automation (IA) is the vast area of embedded computing devoted to industrial applications. Apart from many tailored solutions (numerical controllers, hardware controllers, etc.) the scene is dominated by programmable logic controllers, widely known by the abbreviation PLC, which represent the most wide-spread class of embedded computing platforms. In the past, the progress in embedded technologies has determined qualitative breakthroughs in the performance of automation systems, their affordability and efficiency of their design.

Intelligent industrial automation (IIA) has appeared as a branch of research and development, answering the challenges of flexible and adaptive manufacturing, which require mass customization instead of mass production. It stipulates the use of information and communication technology (ICT) methods and tools for creating self-configurable or easily-reconfigurable control systems to automate manufacturing processes.

The automation systems need to go beyond being a collection of networking PLCs—they should be intelligent in the way that they interact and behave and how they are used by a range of people, from control engineers to maintenance technicians. That is why the newly emerging trends in automation deal with service-oriented architectures, knowledge engineering, and Web-services. Most solutions to safety and predictive maintenance issues are implemented nowadays by such novel embedded solutions as wireless smart sensor networks.

Automation systems research faces the same significant challenges as does the embedded systems world, of which it is an integral part. One of these is the quest for integrated high-level design methods, languages, and tools [1]. In the automation domain this has translated into the development of component-based software architectures supporting visual programming, such as the IEC 61499 standard [2] and strategies for controlling distributed applications [3].

The challenges of designing these applications using embedded technologies are also contributing to the development of the embedded technologies themselves, in turn giving rise to new challenges.

This special issue is organized in collaboration with O[3]neida [4], the global organization, operating as a network of networks to promote distributed industrial automation based upon open standards.

Taking the O[3]neida perspective of the IA value added chain [5] means that an IA solution, developed or deployed by any organization, must include an analysis of the implications on the company's internal processes, on the management of its extended supply chain, all within the context of the complete product life cycle.

O[3]neida has recently extended its interest into new research-intensive application areas of IIA, such as

(i) energy management,
(ii) building automation,
(iii) health over Internet protocol (HoIP).

O[3]neida facilitates collaboration of industrial, academic, and research organizations by providing collaborative frameworks within which to conduct national and international research and development projects.

It also helps with knowledge transfer by supporting new publication initiatives, such as this special issue, or a series of industrial automation books, recently launched with the Instrumentation Society of America.

O^{3}neida also works to develop and promulgate the international standards required to promote interoperable intelligent solutions in automation. For example, the joint paper [3] demonstrates collaboration of O^{3}neida members from 9 organizations worldwide, in the work, aiming at the improvement of the IEC 61499 standard.

Finally, O^{3}neida has recently opened O^{3}neida Europe, its second international node focused on European industrial automation activities. O^{3}neida Asia is expected to be formed later this year.

This special issue is a fine example of the collaboration environment, created by O^{3}neida and enthusiastically supported by its members.

The papers, selected for this special issue, cover a wide spectrum of the automation research, concerning topics such as extending the capabilities of embedded computing platforms, or using them to the benefit of automating demanding manufacturing systems. These papers can be divided onto three thematic groups.

The first group refers to the high-level system engineering in flexible and reconfigurable manufacturing, implementing the idea of system-level languages in the IIA domain, which naturally leads to the new generation of embedded control devices beyond PLCs. In particular, the paper by Ferscha et al. proposes a higher-level design methodology for flexible manufacturing systems with distributed control. The work by Ferrarini et al. applies metamodeling and model-driven architectures techniques for reconfigurable control of manufacturing systems. New programming architectures and methodologies for such controllers, in particular the novel IEC 61499 architecture, are discussed by Gerber et al. and Dubinin et al. Thus, Gerber et al. investigate migration from the currently dominating PLC architecture of IEC 61131-3 to IEC 61499. Dubinin et al. propose a formal syntactic model of IEC 61499, needed to address the issue of its execution semantics.

The second group of papers addresses the solutions enabling intelligent networking, which progresses from simple device connectivity to provision of web-services and the use of service-oriented architectures. The latter imposes new requirements to the resource-constrained embedded platforms. Maciá-Pérez et al. deal with the problem of managing control applications and embedded services in automated equipments through a specialized reference frame of IT services. Collado et al. address the problem of implementing an XML parser on embedded device. The growing popularity of XML makes this work very relevant to many automation applications. Thramboulidis et al. propose the use of service-oriented architectures (SOA) as an integration technology to "glue" different applications, used in the design of intelligent automation systems. López Orozco et al. deal with performance of the FIPA agent-based protocols, which provide a higher-level communication language for intelligent automation nodes.

The third group of papers represents the important area of verification and validation of embedded automation systems. Vyatkin et al. propose a visual specification language to be used in formal verification of modular automation systems.

The works included in this special issue certainly cannot represent the whole body of relevant research. They rather highlight some exciting application areas of advanced embedded technologies. We hope this special issue will facilitate joint research between the industrial automation and the embedded systems research communities.

Luca Ferrarini
Jose L. Martinez Lastra
Allan Martel
Antonio Valentini
Valeriy Vyatkin

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