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Open Invited Track

Transformation of legacy software in manufacturing and logistics systems as enabler for reconfigurable, agent-based automation architectures

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Abstract: Automated production systems, including manufacturing and intralogistics systems, are facing increasing challenges to adapt to the recent technological leaps in the context of Industry 4.0 and to compete on the global market by ensuring evolvability to changed requirements during lifecycles of several decades. Agent-based automation architectures have proven as suitable means to enable adaptable production systems and to automatically reconfigure such systems in case of faulty or broken physical components enabling continuing operation instead of downtime. One key challenge to the applicability of such agents is the creation of individual knowledge bases, e.g., based on engineering models, common ontologies or by learning from operational data during operation of manufacturing and logistics. Additionally, the implementation of multi-agent systems in manufacturing requires modular, evolvable automation software. In reality, however, automation software does often not evolve systematically but is enlarged by extensions in the code to implement new requirements as quickly as possible, leading to historically grown legacy software that is difficult to maintain and reuse. For a successful integration of agent-based approaches in industry, it is essential to migrate the domain knowledge of controlled processes from existing legacy software rather than restarting from scratch. Thus, this Open Invited Track aims to present innovative approaches on the analysis, refactoring, and quality assurance of modular automation software as well as on reconfigurable, agent-based automation architectures.

IFAC technical committee: IFAC TC3.1 “Computers for Control”

Detailed description of the topic: The Open Invited Track shall include approaches and methods for the sustainable improvement of automation architectures to enable existing manufacturing and logistics systems for Industry 4.0 and to bring concepts such as agent-based automation architectures into industrial practice [1]. In particular, the trend towards short-term changeover to new products requires greater flexibility and adaptivity for automated manufacturing and logistics systems, which can often only be realized via modified automation software [2]. Recently, the demand for resource efficiency, including low energy-consumption, adaptability and evolvability is gaining importance. The increased global competition, including cost and time pressure, requires higher quality and efficiency in engineering and operation of long-living, automated manufacturing and logistics systems. Agent-based automation architectures are a key enabler to meet requirements posed by Industry 4.0 and enable lean, energy- and resource-efficient production processes. However, bringing agent-based approaches into industrial practice requires the migration of historically grown legacy systems towards modular, reconfigurable automation architectures. A major part of system functionality is implemented via automation software, which does often not evolve systematically but is enlarged by undocumented extensions in the code to implement new requirements on short notice, leading to historically grown legacy software that causes issues during maintenance [3]. Thus, refactoring and transforming existing legacy software to enable evolvability via systematic reuse is a crucial prerequisite for agent-based automation architectures. This requires sophisticated approaches in measuring, improving, and assuring automation software quality to ensure modularity already in the design phase, which opens up further savings potential and thus leads to an overall competitive advantage for companies [4]. A recent study of 68 companies from the German machine and plant engineering sector [4] found that many of the success factors for reusable software modules are implemented in only a few companies. In terms of quality assurance, e.g., 10% of the interviewed companies rely solely on tests during commissioning. In addition, it was shown that 63% of machine manufacturers and 45% of plant manufacturers do not use automatic code configuration. However, software has long been the decisive factor for the success of a company and the differentiation of its products from those of its competitors [5, 6]. Targeted code analysis and optimization can support the identification of improvement potential in the software and thus, serve as a precursor for the entry of agent-based systems into industrial practice.

The track will cover all topics related to analysis and refactoring of modular automation software as well as agent-based approaches in manufacturing and logistics systems, including (but not limited to) the following keywords:

- Code analysis of automation software in manufacturing and logistics systems
- Practicability of code analysis in industrial practice
- Workflow integration of code analysis and optimization
- Data flow analysis within and across PLCs
- Retrofit of existing systems for Industry 4.0
- Efficient test management in large-scale automation systems
- Agent architectures and patterns
- Data driven automation
- Distributed agent systems and learning
- Autonomy and AI for agents
- Creation of agent knowledge base
- Digital twins in the context of agents systems and Industry 4.0
- Agents in the supply chain/ agents in decision networks
- Reliability of and trust in autonomous systems

[1] H. Baumgärtel and R. Verbeet, "Service and Agent based System Architectures for Industrie 4.0 Systems," *NOMS 2020 - 2020 IEEE/IFIP Network Operations and Management Symposium*, 2020, pp. 1-6.
[2] B. Vogel-Heuser, E. Neumann, J. Fischer, M. Marcos, E. Estévez Estévez, G. Barbieri, L. Sonnleithner and R. Rabiser, "Automation Software Architecture in CPPS – Definition, Challenges and Research Potentials," *ICPS 2022: 5th IEEE International Conference on Industrial Cyber-Physical Systems (ICPS)*, IEEE, May. 2022, pp. 1-8.
[3] J. Ladiges, C. Haubeck, A. Fay and W. Lamersdorf, "Semi-automated decision making support for undocumented evolutionary changes," *Workshop Software-Reengineering & Evolution (WSRE)*, 2014.
[4] B. Vogel-Heuser and F. Ocker. "Maintainability and evolvability of control software in machine and plant manufacturing - An industrial survey," *Control Engineering Practice*, vol. 80, no. 1, pp. 157-173, 2018.
[5] A. Zoitl, and T. Strasser, eds. Distributed control applications: guidelines, design patterns, and application examples with the IEC 61499. CRC Press, 2017.
[6] A. Fay, B. Vogel-Heuser, T. Frank, K. Eckert, T. Hadlich and C. Diedrich, "Enhancing a model-based engineering approach for distributed manufacturing automation systems with characteristics and design patterns," *Journal of Systems and Software*, vol. 101, pp. 221-235, 2015.