Modularity and architecture of PLC-based software for automated production Systems: An analysis in industrial companies

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Abstract: Adaptive and flexible production systems require modular and reusable software, especially considering their long-term life cycle of up to 50 years. We introduce a benchmark process – so-called SWMAT4aPS – to measure software maturity for industrial control software of automated production systems.

Keywords: Automated Production Systems, Maturity, Modularity, Control Software

1 Introduction to SWMAT4aPS benchmark process

Automated production systems (aPS) are long living systems that are exposed to changes over decades. Their complexity including automation hardware as well as system functionality realized by software is increasing. The ability to adapt flexibly to changing requirements by replacing or expanding cross-disciplinary modules, tracing of changes and management of software variants and versions are a prerequisite for intelligent, self-organizing Industry 4.0-compliant aPS. To evaluate whether industrial control software is qualified for Industry 4.0, the benchmark process SWMAT4aPS (Software Maturity for aPS) was developed. SWMAT4aPS consists of two elements, a self-assessment questionnaire and a detailed expert analysis for selected industrial companies. The core of the approach consists of four steps, which are performed in an experimentation and reporting phases. The first step is to conduct a survey with the developed questionnaire, which contains 45 questions grouped into three maturity categories. Maturity in design, maturity in test/quality assurance and maturity in start-up/operation/maintenance. In the second step the questionnaires' results of 16 German world-leading companies in machine and plant manufacturing are analysed (cp. Fig 1). The third step is the expert analysis in which four selected companies' software architecture, code structure and the workflow were analysed. We prove the validity of SWMAT4aPS by comparing the results of the questionnaire with the results of the expert analysis. The best companies reached overall maturity values of 0.86 %. We identified a huge variation of maturity levels in most of the companies, some have high values in design, others in start-up and operation. Refer to the full paper [VF17] for a complete discussion of results.

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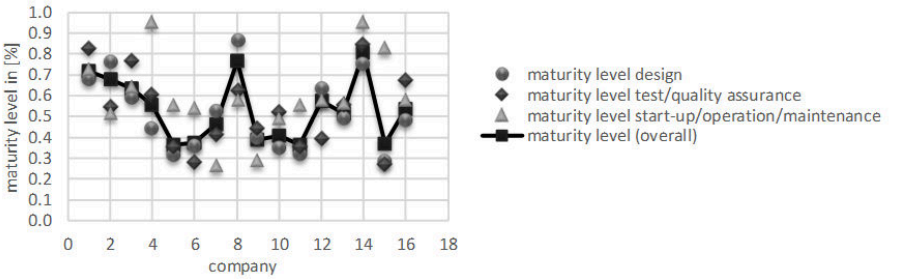

Fig. 1: Overview of maturity levels of companies 1 to 16 from first questionnaire showing the huge variance in the individual company regarding the three different maturity values

To further elaborate the differences between the wide range of machine and plant manufactures, to reveal modular dependency effects and to get deeper insight into the use of software module a second questionnaire was conducted with more than 68 companies. Results of design level of the industrial control software regarding factors for cross-disciplinary modularization are depicted (cp. Fig 2). The detailed analysis confirmed that the SWMAT4aPS approach delivers valid results and gives a first overview of the state of the art in software engineering in the respective company compared to others of the same branch. In a third questionnaire with more than 70 companies we strengthened the aspects of electrical engineering and included technical debt aspects and their reasons and impact.

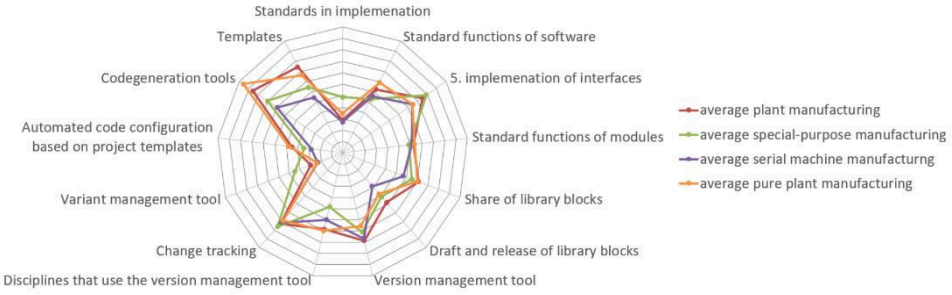

Fig. 2: Maturity level design of control software of 68 companies in machine and plant manufacturing from second questionnaire

2 References

[VF17] Vogel-Heuser, Birgit; Fischer, Juliane; Feldmann, Stefan; Ulewicz, Sebastian; Rösch, Susanne: Modularity and Architecture of PLC-based Software for Automated Production Systems: An analysis in industrial companies. The Journal of Systems & Software 2017, Elsevier, doi:10.101016/j.jss.2017.05.051.