Summary of the doctoral dissertation

titled *Methodology of modeling, testing, and implementation of control software with the usage of SysML diagrams and unit tests*

(in Polish: Metodyka modelowania, testowania i implementacji oprogramowania sterującego przy użyciu diagramów SysML oraz testów jednostkowych)

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The aim of the dissertation is to propose the methodology of modeling, testing, and implementation of control software created according to the updated version of the IEC 61131-3 standard published in 2013. The main assumptions of the methodology specify that the development process is based on a model and tests, uses components, supports agility and allows to use already existing code in the IEC 61131-3 languages. What is more, the methodology promotes reusing various parts of a project, generating the implementation in an automatic way, as well as using the round-trip engineering concept.

The main thesis in the dissertation consists of the statement that it is possible to create a methodology of modeling, testing, and implementation of control software that combines selected rules of model-driven and test-driven development. The dissertation also contains three auxiliary theses.

Inclusion of the modeling phase in the overall software development process allows to use the MDD (*Model-Driven Development*) paradigm and increases the abstraction level. To achieve this, a dedicated domain-specific language has been proposed. The language is based on the SysML (*Systems Modeling Language*) profile of the UML (*Unified Modeling Language*) metamodel, and uses all types of SysML diagrams together with a set of modeling rules to specify a way of modeling of particular elements from IEC 61131-3-based systems. The methodology supports modeling of POUs (*Program Organization Units*), user data types, POU behavior as state machine, system structure, global variables, tasks, communication, HMI (*Human-Machine Interface*), functional and non-functional requirements, use cases, as well as viewpoints adjusting the set of information presented to engineers.

Importance of testing in the development process has been increased as well. The methodology supports the TDD (*Test-Driven Development*) paradigm and uses a set of testing methods to check functional and non-functional requirements. From the methodology point of view, the most important are tests oriented towards POUs created in the dedicated test definition language CPTest+. Such a language allows to create parameterized test cases, replace selected POUs with mock objects, as well as prepare the environment before testing. POUs can be also tested using table and visual tests. Additionally, the methodology supports POU performance tests and tests of communication between devices in a distributed control system. A dedicated way of HMI testing allows to verify requirements related to displays.

The proposed methodology supports the agile software development process and should make it possible to react faster to necessary changes, as well as to adjust the project to altered requirements in an easier way. Moreover, it allows to automatically generate a part of implementation by using information from the model, what is a practical application of the forward engineering. The dissertation also proposes the concept of round-trip engineering dedicated to IEC 61131-3 control system projects.

The dissertation contains six chapters and three appendixes. The main part consists of four chapters where the methodology concept and essential stages (modeling, testing, implementation of control software) are presented. The first appendix describes the CPDev engineering environment, which has been used in the dissertation. The hierarchy of packages in the model created according to the proposed methodology is shown in the second appendix. The list of all instructions supported by the CPTest+ test definition language is presented in the last appendix.

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