Ontology-based Development of the Metamodels for Modelling Distributed Parallel Software Systems

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***Abstract*—The paper proposes the method for the development of metamodels for the modelling distributed parallel software systems. The method is an important stage of Domain-Specific Mathematical Modelling (DSMM), developed to enhance the methodology of Domain-Specific Modelling. The advantage of DSMM is a possibility of constructing metamodels for the modelling domains, having different mathematical properties and structures. The paper analyses applicability of OWL-DL ontologies for expressing properties of software systems. Identification of the metatypes as OWL classes and use of OWL restrictions as metamodels' grammars give us an effective way for the design and verification of software systems. The proposed approach have advantages of the model driven software development and allows verification of software systems at earlier design stage.**

Keywords-ontology, metamodel, domain specific mathematical modelling, parallel software system, logical analysis.

I. INTRODUCTION

The methodology of Domain-Specific Modelling (DSM) becomes more and more popular in the modern software engineering [1-4]. The essence of DSM is a construction of metamodels and their application for the modelling domains with the purpose of software systems development.

Despite of the power of DSM, its theoretical base and practical implementation have several drawbacks. To overcome these limitations we proposed the methodology for Domain Specific Mathematical Modelling (DSMM) [5]. Its advantage is a possibility of development of metamodels for the modelling domains, having different mathematical properties and structure [6]. Architecture of implementing DSMM software tools was described in [7].

In our previous works, we consider the method for the development of metamodels as logical and algebraic systems [8]. For example, we use vector algebra and logic of syllogisms to produce the metamodel called "vector logic" [9]. Here, the model of a domain consists of the syllogisms, which are instances of the metamodel' types "logical vectors". Vector algebra was used to define algebraic metatypes, rules of the metamodels' grammar and corresponding methods. In particular, the new method for the reasoning was proposed, where the inference is the sum of the logical vectors that represent given as syllogisms assumptions.

In this paper, we expand DSMM approach by application of OWL-DL [10] ontologies for the development of metamodels and further modelling software systems. We consider ontological modelling as an important stage of the DSMM. Feasibility of using ontologies for the metamodels development we prove on examples of modelling and validation of properties of distributed parallel software systems. Web Ontology Language (OWL) [10] we also use for the modelling network of distributed computing nodes.

This paper is organized as follows. First, we discuss the method for the development of the metamodel for modelling software systems on the base of OWL-DL. Next, we consider an example of ontology development for the modelling topology of computing nodes of distributed software system. Conclusions and prospects for the future research finalize the paper.

II. MATERIAL AND METHODS

Modern market of software (SW) and hardware (HW) systems needs reducing cost and increasing functionality of computer systems. In addition, modern HW and SW systems have reached the level of complexity, for which the requirements of safety and fault tolerance are crucial. That is why the development of technology for modelling computers systems that allows their verification at earlier design stage is an actual scientific and technical problem.

Let us consider the applicability of DSMM for the development of metamodels for modelling software and hardware systems. We consider conceptual modelling, including formulation of requirements and specifications, as a first phase of any system development.

In [11] we propose an ontological metamodel for the specification of software systems with natural language. Using this conceptual metamodel allows us to structure initially disjoint requirements and specifications, make their unification, and highlight different aspects of a system design. However, structuring of statements about future system properties within a certain conceptual scheme does not limit the feasibility of ontological metamodelling.

OWL is actually a family of logics that have significantly different properties. In particular, OWL-DL (DL is a Description Logic [12]) allows us to verify properties of software systems by means of special tools for logical analysis (so called reasoners, e.g. FACT++ [13]). Specification of a software system with OWL-DL provides a combination of two most important stages of software development: conceptual modelling (specification of requirements) and formal verification of software properties.