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Mathématiques, Télécommunications, Informatique, Signal, Systèmes, Électronique

Spécialité : « voir README et le site de votre école doctorale »

Par

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- « Titre de la thèse »
- « Sous-titre de la thèse »

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Je tiens à remercier
I would like to thank. my parents..
J'adresse également toute ma reconnaissance à ....
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INTRODUCTION

Context and Motivation

Software systems are exponentially growing, which leads to a substantial burden in terms of maintenance, often resulting in a high cost that may surpass the cost of software development itself [4]. Since Object Management Group (OMG) has introduced Model driven Engineering in 2001 [2], MDE has been prominent in developing and maintaining large-scale and embedded systems while increasing the developers' productivity. By adopting MDE, industry can reduce time (development time, time-to-market), costs (development, integration, reconfiguration), and improve sustainability and international competitiveness [11, 26]. MDE raises the abstraction level to the "metamodel" artifact in order to separate the implementation from the business logic. Metamodel is a central artifact for building software languages [3]. It specifies the domain concepts, their properties, and the relationship between them. A metamodel is the cornerstone to generate model instances, constraints, transformations, and code when building the necessary language tooling, e.g. editor, checker, compiler, data access layers, etc. In particular, metamodels are used as inputs for complex code generators that leverage on the abstract concepts defined in metamodels. The generated code API for creating, loading and manipulating the model instances, adapters, serialization facilities, and an editor, all from the metamodel elements. This generated code is further enriched by developers to offer additional functionalities and tooling, such as validation, transformation, simulation, or debugging. For instance, UML ¹ and BPMN ² Eclipse implementations rely on the UML and BPMN metamodels to generate their corresponding code API before building around it all their tooling and services in the additional code.

^{1.} https://www.eclipse.org/modeling/mdt/downloads/?project=um12

^{2.} https://www.eclipse.org/bpmn2-modeler/

Challenges

C1: Resolve the impact of the metamodel evolution on the code automatically

One of the foremost challenges to deal with in MDE is the impact of the evolution of metamodels on its dependent artifacts. We we focus on the impact of metamodels' evolution on the code. Indeed, when a metamodel evolves and the core API is regenerated again, the additional code implemented by developers can be impacted. As a consequence, this additional code must be co-evolved accordingly by executing a resolution for each impacted part of the code.

However, manual co-evolution can be tedious, error-prone, and time-consuming. Therefore, it is essential to support an automatic co-evolution of code when metamodels evolve. The co-evolution challenge has been extensively addressed in *MDE*. In particular, [24, 14, 23, 13, 12, 28] focused on consistency checking between models and code, but not its co-evolution. Other works [27, 20] proposed to co-evolve the code. However, the former handles only the generated code API, it does not handle additional code and aims to maintain bidirectional traceability between the model and the code API. The latter supports a semi-automatic co-evolution requiring developers' intervention. Moreover, it does not use any validation process to check the correctness of the co-evolution and with no comparison to a baseline.

Considering that metamodel and co-evolution is one of many other MDE tasks like for example Model generation, code generation. Since their appearance, LLMs have been applied in different domains of scientific research, such as Software Engineering and Model-Driven Engineering (MDE), however, the challenge of exploring LLMs in the task of metamodel and code co-evolution is never addressed.

C2: Behavioral correctness of the metamodel and code co-evolution

In literature, when the problem of metamodel and code co-evolution is addressed, the challenge of checking that the co-evolution impacted or not the behavioral correctness of the code is not handled. In any Model-driven engineered system, the elements of the metamodel are used un the code. The evolution of the metamodel will be propagated in the code that is co-evolved and its behavior may be altered. Hence, the importance of checking the correctness of the co-evolution.

Contributions

To tackle these challenges, we propose three contributions :

- First, we propose a fully automatic code co-evolution approach du to metamodel evolution based on pattern matching. Our approach handles both atomic and complex changes (ref) of the metamodel.
- Second, we investigate the ability of LLMs in giving correct co-evolutions in the context of metamodel and code co-evolution
- Third, w propose an approach that assist developers to check the behavioral correctness of the co-evolution. This approach leverages unit tests before and after the co-evolution and gives visual report about passing, failing, and errounous tests before and after the co-evolution.

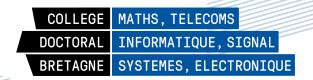
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Titre: titre (en français).....

Mot clés : de 3 à 6 mots clefs

Résumé: Eius populus ab incunabulis primis ad usque pueritiae tempus extremum, quod annis circumcluditur fere trecentis, circummurana pertulit bella, deinde aetatem ingressus adultam post multiplices bellorum aerumnas Alpes transcendit et fretum, in iuvenem erectus et virum ex omni plaga quam orbis ambit inmensus, reportavit laureas et triumphos, iamque vergens in senium et nomine solo aliquotiens vincens ad tranquilliora vitae discessit. Hoc inmaturo interitu ipse quoque sui pertaesus excessit e vita aetatis nono anno atque vicensimo cum quadriennio imperasset. natus apud Tuscos in Massa Veternensi, patre Constantio Constantini fratre imperatoris, matreque Galla. Thalassius vero

ea tempestate praefectus praetorio praesens ipse quoque adrogantis ingenii, considerans incitationem eius ad multorum augeri discrimina, non maturitate vel consiliis mitigabat, ut aliquotiens celsae potestates iras principum molliverunt, sed adversando iurgandoque cum parum congrueret, eum ad rabiem potius evibrabat, Augustum actus eius exaggerando creberrime docens, idque, incertum qua mente, ne lateret adfectans, quibus mox Caesar acrius efferatus, velut contumaciae quoddam vexillum altius erigens, sine respectu salutis alienae vel suae ad vertenda opposita instar rapidi fluminis irrevocabili impetu ferebatur. Hae duae provinciae bello quondam piratico catervis mixtae praedonum.

Title: titre (en anglais).....

Keywords: de 3 à 6 mots clefs

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