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Preface

Preface to the Construction and Quality Assurance of Domain-Oriented Software Systems

Minxue Pan (潘敏学)[1,2], Jun Wei (魏峻)[3], Zhanqi Cui (崔展齐)[4]

[1] (State Key Laboratory for Novel Software Technology at Nanjing University, Nanjing 210023, China)

[2] (Software Institute, Nanjing University, Nanjing 210093, China)

[3] (Institute of Software, Chinese Academy of Sciences, Beijing 100190, China)

[4] (Computer School, Beijing Information Science & Technology University, Beijing 100101, China)

Corresponding author: Minxue Pan, mxp@nju.edu.cn; Jun Wei, weijun@iscas.ac.cn; Zhanqi Cui, czq@bistu.edu.cn

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With the flourishing of Internet, cloud computing, and Artificial Intelligence (AI), novel software technologies and software system architectures have been emerging, upgrading, and further integrated with the Internet of Things (IoT), industrial control, autonomous driving and other fields to form software systems and platforms with unique characteristics. The development is leading and promoting the digital and intelligent development of these fields and bringing opportunities for the accelerated evolution and innovative development of the society and the economy. Compared with conventional software systems, domain-oriented software systems (briefed as domain software) have new challenges in research and application. Considering the characteristics and demands of domain software, one may find it is a great challenge to implement the software definition and intelligence of domain applications, and strictly guarantee the important quality characteristics (e.g., correctness, real-time performance, and synergy) of system control behaviors, by multiple methods including verification, analysis, and test.

One of the important characteristics of domain software is that it needs to be able to bear and deal with domain characteristics. The focus of domain software varies among different fields. This special issue focuses on the emerging fields such as IoT, blockchain, and autonomous driving. IoT represents a new stage in the development of ubiquitous network established on the basis of Internet. By interconnecting various sensors, intelligent processing terminals, etc., IoT can achieve the connection between things and things as well as between things and people anytime, anywhere, thereby realizing intelligent management and control. Since IoT is a promising technology that is considered to promote the change of lifestyle in modern society, studies need to be carried out on hot spots such as Radio Frequency IDentification (RFID), wireless sensor networks, and IoT network protocols. Furthermore, the software systems and platforms should be constructed to control network hardware behaviors, provide reliable communication protocol implementations, and effectively manage the application tasks completed by various IoT devices, device interactions, and device collaborations. Moreover,

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IoT software systems are not limited to the aforementioned aspects. All the issues, such as collecting massive information, forming the intelligent behavior of group network by information aggregation, making devices better interconnected and interoperable, and enabling devices to adapt to the environment and provide autonomous behavior, need to be considered for the more intelligent decision-making and more flexible device control of IoT software systems and platforms.

The core of a blockchain system is to use distributed data storage, peer-to-peer communication, encryption algorithms, consensus mechanisms, and incentive mechanisms to achieve an effective collaboration among distributed nodes in a decentralized manner. The balance between security and efficiency is one of the important issues to be studied for the blockchain system. The development of secure and effective consensus mechanisms to defend against attacks is a particularly difficult issue. Efficiency, as an important factor restricting blockchain applications, is also a core topic to be studied, and it needs to design better algorithms to improve the efficiency of storage and transactions. It is worth mentioning that the rapid application of blockchain technology at present benefits from the programmable feature of smart contracts. Therefore, researchers highly concern about the correctness of smart contracts, and have applied multiple software quality assurance technologies such as vulnerability detection, malicious code detection, and formal verification in smart contracts. In terms of application, blockchain technology and smart contracts can be applied to all sectors such as IoT, manufacturing, finance, medical care, and agriculture. The aforementioned domain of IoT is also achieving decentralized organization by means of blockchain, and realizing the automation of complex application tasks through smart contracts.

Autonomous driving involves multiple disciplines such as automatic control, AI, computer vision, and software engineering. The relevant research of software engineering mainly focuses on the quality assurance of automatic driving systems, which aims to comprehensively guarantee the correctness and reliability of the automatic driving system by modeling, simulating, testing, and verifying the system and its environment. The research objects can be roughly divided into two categories: the key functional components of the system and the overall system. Most of the available studies focus on single functional components, including perception components, decision-planning components, and control components. The boundaries of the components sometimes overlap and merge to form subsystems. For example, the method based on deep neural networks, which has been extensively studied at present, integrates environment (image) perception and driving decision-making. The quality assurance of the overall system is rarely reported, and it deserves the attention of researchers. In addition to the classical issue of validity, generating a large amount of representative input in the presence of cost constraints is also an important issue in the quality assurance technologies (e.g., simulation, testing, and verification) due to the diversity and complexity of the inputs for autonomous driving.

The in-depth integration of the software with the domain will place different emphases on the characteristics of the constructed domain software. For example, the requirement is higher for the security of software in the industrial control field and for the development efficiency of software in the mobile field. Therefore, this special issue focuses on the methods and techniques to improve the attributes of specific software. Fuzzy testing and symbolic execution are two effective methods for defect detection. Fuzzy testing exhibits the disadvantage of barely covering narrow constraints as it fails to pay attention to path conditions. Symbolic execution faces the problems such as path explosion and capability limitation of constraint solvers, and is unable to cover the program space comprehensively and quickly, despite its ability of handling narrow constraints. Therefore, optimizing fuzzy testing and symbolic execution must be considered when software technology is combined with domains with high-quality demands, such as industrial control.

Facing the need for the rapid iteration of software, developers are required to be able to efficiently fix defects and upgrade software version. It becomes a topic of interest of software researchers to improve development efficiency by designing automated and intelligent technical means.

In this special issue, five representative papers focusing on the aforementioned directions are chosen.

In the paper "*Approach to Generating TAP Rules in IoT System Based on Environmental Modeling*", a TAP rule generation approach based on environmental modeling is proposed for managing and controlling IoT devices of smart buildings and smart homes, which automatically derives system behavior from service requirements based on the environmental model, detects the integrity and consistency of the system behavior, and finally generates TAP rules.

In the paper "*Efficient Blockchain-Empowered Data Sharing Incentive Scheme for Internet of Things*", the method based on blockchain incentive mechanism for data-sharing and improving sharing efficiency in IoT systems is investigated. A sharding technology is employed to build asynchronous consensus zones that are capable of processing data-sharing transactions in parallel, and efficient consensus mechanisms on the cloud/edge servers and the sharded asynchronous consensus zones are deployed to improve the processing efficiency of data-sharing transactions.

In the paper "*A Meta-Modeling Approach for Autonomous Driving Scenario Based on STTD*", a Spatio-Temporal Trajectory Data (STTD) meta-modeling method oriented to autonomous driving scenarios is proposed to realize the unification, processing, and reuse of data. The use of the Adaptive Domain-Specific Modeling Language (ADSML) to instantiate a scene is then discussed.

In the paper "*Deep Learning-Based Hybrid Fuzz Testing*", a deep learning-based hybrid testing method that combines symbolic execution and fuzzing is proposed considering the respective advantages and disadvantages of symbolic execution and fuzzing methods. The corresponding hybrid testing tool, SmartFuSE, is then designed.

In the paper "*Structurally-Enhanced Approach for Automatic Code Change Transformation*", automatic conversion of similar codes in the course of code changes is studied. A deep learning-based, structurally-enhanced approach for automatic code change transformation method is proposed. This method enhances the model's ability to capture the structure information and dependency information of the code, thereby improving the accuracy of automatic transformation of code changes.

This special issue is oriented to the researchers and engineers in domain software, with the contents covering various fields of domain software, such as requirement analysis, design and modeling, development and construction, testing and verification, reflecting the high-level research achievements of Chinese researchers in related fields. We hope this special issue can provide insights to the studies of domain software.

Minxue Pan Ph.D., associate professor at the Software Institute, Nanjing University, CCF professional member. His research interests include software system modeling and verification as well as software analysis and test.

Jun Wei Ph.D., researcher and doctoral supervisor at the Institute of Software, Chinese Academy of Sciences, CCF senior member. His research interests include evaluation and optimization of distributed software system architectures as well as reliability assurance of distributed systems.

Zhanqi Cui Ph.D., associate professor at the Computer School, Beijing Information Science & Technology University, CCF professional member. His research interests include software analysis and testing technology as well as reliability assurance of intelligent software.