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Formalisms for Reuse and Systems Integration

Springer

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Preface

Reuse and integration serve as the basis of most contemporary computer science and technology. They support, in a complementary way, software and system design for low cost and are associated with high performance. The low cost is induced by capitalization of previously learned knowledge through simple reuse; whereas high performance arises out of the improvement of already acquired knowledge through reuse after transformation and/or integration. Reuse and integration are also defined as complementary concepts, where reuse deals with the creation and exploitation of components; while, integration focuses on how reusable components interact to yield reusable composites. Integration is thus designed as the process of reuse analysis followed by that of new patterns synthesis. Formal methods, as far as they are concerned, provide the appropriate context to handle reuse and integration in a rigorous way. Formal languages allow for non ambiguous model specification; and, formal verification techniques serve as a support for checking reuse and integration mechanisms.

In such a context, formal methods are first employed to prove or disprove safety properties of the designed components at early stages of the development process. They are subsequently deployed to help assure consistency of the assembled components. Model-checking is one of the most commonly used verification techniques. It provides a good compromise between reliability of checking and complexity of use. Chapter 1 considers specification-based testing for linear temporal properties expressed in generalized Büchi automata. The developed test criteria measure the semantic relevancy as well as the quality of existing test cases with respect to requirements in the specification. Automated test-case generation for the proposed criteria is then performed. Chapter 2 introduces a methodology for specification and model-checking of Interacting Combined Fragments, where the whole process of modeling and analysis is described. A denotational semantics is first defined for the Combined Fragments. Next, a process of formal analysis – including both verification and validation tasks is developed. It is distinguished by the assistance that it provides to developers. An interpreted feedback of the formal analysis is returned to them in their chosen language for specification. In Chapter 3, an approach to reduce the verification effort is presented through a counterexample-guided abstraction refinement (CE-GAR) method. Safety-relevant parts of the complex system dynamics are considered in the verification process. The latter is conceived so that it does not require restarting the reachability analysis after each refinement step. Rather, the refinement is embedded into the reachability analysis process in order to prevent this process from repeatedly re-checking the same model behavior. A stronger formal method is reported in Chapter 4. It consists of a new application of theorem proving to verify the imaging properties of optical systems. The notion of composed optical systems is formalized. Then, the property stating that composed systems inherit the same linear algebraic properties as for the case of a single optical system is verified.

Temporal aspects constitute critical criteria for software and system design. They require specific formalisms for their specification and verification. Chapter 5 proposes a new approach that supports a multi-server paradigm for handling multiple semantics within the same specification. The purpose of such an approach is to deal with complex system formalization. To achieve this, Time Petri Nets are extended to support the expression of two different semantics related to enabledness; namely, the Age semantics and the Threshold semantics. These two semantics are interpreted on the Petri net according to the specification needs. The proposed method offers a very compact expression of the model semantics by reducing the amount of data in the state definition. Time Petri Nets are also used in Chapter 6 to provide a denotational semantics for the Interaction Overview Diagrams and Timing Diagrams augmented by UML-MARTE annotations. To check the model correctness, timed temporal properties are used. They are first written by the designer in the Object Constraint Language (OCL). Next, they are translated into Timed Computation Tree Logic (TCTL) formulas. They are finally evaluated by model checking on the derived Time Petri Net. As to Chapter 7, it relies on distribution and concurrency to carry out real-time modeling and formalization. It provides the process-based language BPEL with an operational semantics defined by a distributed real-time model. True concurrency semantics is proposed to deal with the timed behavior of the language composition. Then, timed value-based temporal logic properties are verified by model checking.

Reuse and integration are key concepts in data warehouse and data mining. They offer the rudiments for an appropriate storage of the information – thus facilitating its extraction and enhancing its usefulness. Information extraction generally relies on users' requirements. However, the selection of appropriate components for building a system is a difficult task – especially when non-functional requirements are taken into account. To address this issue, Chapter 8 proposes an approach to decompose the user requirements into lower level requirements with the help of an ontology. Sets of components satisfying the functional requirements are checked for compliance with non-functional requirements and chosen accordingly. The proposed model integrates the necessary transformations including traceability links between user requirements and a solution to facilitate system evolution and maintainability. Another issue in data warehousing refers to data integration of heterogeneous sources. This may be addressed based on a popular approach, which consists of a process to Extract, Transform, and Load (ETL) data from disparate sources into a consolidated data store. Thus, Chapter 9 focuses on the integration of tree-like hierarchical data or information. Given the observed complexity in developing ETL processes for this particular but common type of data, the proposed approach allows for reducing the time and effort required to map and transform the data. The work automates and simplifies all possible transformations involving ranked self-referential and flat representations.

The capability to extract knowledge based on reuse is also of potential interest. Research on link-based classification addresses methods to improve the accuracy of inference. In Chapter 10, an experimental study is carried out to compare latent and non latent methods. New methods are proposed, based on the resulting observations, which leverage latent techniques in novel ways. Two of these methods combine a latent method with an existing non-latent method, while one new method presents the first useful combination of a latent feature method with a latent link method. The results obtained demonstrate that a non-latent method usually continues to obtain the best performance; but, these new hybrid methods can sometimes increase accuracy when the network is very sparsely labeled. Some research works also deal with the inference of profile attributes of writers, with high accuracy, based on their texts. This may be useful for a range of critical applications, such as security – enabling automatic enhancement of users' profiles for extended analysis. Author age appears more difficult to determine than some other attributes; but previous research has been somewhat successful at classifying age as a binary, ternary, or even as a continuous variable using various techniques. Chapter 11 shows that word and phrase abbreviation patterns can be applied towards determining user age by way of novel binning, as well as towards determining binary user gender and ternary user education level.

Researchers also argue for better methods to support specification and reasoning on knowledge components. In Chapter 12, the focus is on how to maintain contradiction-free knowledge in front of an incoming piece of information that possibly contradicts the preexisting knowledge. In this respect, the proposed approach adopts a practical and realistic computational stance towards handling contradictory knowledge. Inspired by human beings, the experimental solution aims to handle conflicting knowledge in any time frame. This is accomplished through a progressive range of reasoning capabilities that are successively triggered and that depend on the amount of consumed computational resources. Addressing all patterns of reasoning ensures that the resulting knowledge is non-contradictory.

This edited book includes 12 high quality research papers written by experts in formal aspects of reuse and integration to cover the most recent advances in the field. These papers are extended versions of the best papers which were presented at the IEEE International Conference on Information Reuse and Integration and the IEEE International Workshop on Formal Methods Integration, which were held in San Francisco in August 2014. They have been selected from 132 accepted papers and have been retained for publication in this book after being extended and undergoing a rigorous peer review process.

January 2, 2015

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