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Osman Hasan
Falah Awwad
Nabil Bastaki

Formal Analysis of Future Energy Systems Using Interactive Theorem Proving

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Asad Ahmed
School of Electrical Engineering
and Computer Science (SEECS)
National University of Sciences
and Technology (NUST)
Islamabad, Pakistan

Osman Hasan
School of Electrical Engineering
and Computer Science (SEECS)
National University of Sciences
and Technology (NUST)
Islamabad, Pakistan

Falah Awwad
Department of Electrical Engineering
United Arab Emirates University
Al-Ain, United Arab Emirates

Nabil Bastaki
Department of Electrical Engineering
United Arab Emirates University
Al-Ain, United Arab Emirates

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To our families

Preface

Smart grids are large and complex networks which mainly employ information and communications technologies (ICT) to ensure cost-effective, efficient, secure and reduced carbon emission energy utilization. Traditionally, paper-and-pencil and simulation methods are used to analyze various aspects of smart grid functionalities. However, these techniques suffer from severe, inherent, limitations in terms of scalability and accuracy. This book presents a theorem proving based logical framework for conducting an accurate analysis of safety- or mission-critical aspects of smart grids. The analysis using this logical framework is highly reliable due to the sound and complete nature of the theorem-proving technique.

The book presents the higher-order-logic formalizations of stability, microeconomics models of cost and utility function and asymptotic theory. These formalizations provide higher-order logic models of the aforementioned theories and their formally verified characteristics within the sound core of the HOL Light theorem prover. These formalizations are then employed to formally verify power converter design, cost and utility models and asymptotic bounds of online scheduling algorithms in smart grids.

The book starts with a brief introduction (Chap. 1) to smart grids in the perspective of energy processing, microeconomics modeling and algorithm design requirements. An overview of the HOL Light theorem prover and its library formalization related to the proposed formalizations is presented (Chap. 2). The formalizations and smart grid applications are presented in the rest of the book (Chaps. 3–5). Finally, Chap. 6 concludes the book.

The target audience of this book are engineers and scientists working in the domains of system analysis and formal methods. These system analysis experts would be able to learn about the potential applications of formal methods, especially, in the safety- and mission-critical applications of smart grids. On the other hand, the online availability of the mechanized proofs provides an opportunity to practitioners to apply these generic formalizations to many other safety- and mission-critical engineering applications, which use these mathematical notions. The whole idea of using

theorem proving for smart grids has a great potential to ensure the safe and secure implementation of these state-of-the-art future energy systems.

Islamabad, Pakistan — Asad Ahmed
Islamabad, Pakistan — Osman Hasan
Al-Ain, UAE — Falah Awwad
Al-Ain, UAE — Nabil Bastaki
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