

Runtime Verification

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Runtime Verification

A Hands-On Approach in Java

 Springer

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Contents

1	The Need for Verification	1
1.1	The Rise of Algorithms and the Need for their Correctness ..	1
1.2	What is at Stake?	3
1.3	Why is Software Failure so Common?	4
1.4	Some Pertinent Questions	6
2	What is Runtime Verification	9
2.1	Testing and Exhaustive Analysis	9
2.2	What is Runtime Verification?	10
2.3	Programming Runtime Monitors and Verifiers	12
2.4	Choices in Runtime Verification	13
2.5	Conclusions	15
3	FiTS: A Financial Transaction System	17
3.1	Understanding the Structure of FiTS	17
3.2	FiTS Repository	18
3.3	The Modules	19
3.4	Is FiTS Fit for Purpose?	24
3.5	The Scenarios and their Execution	26
3.6	Conclusions	27
4	Manual Monitoring	29
4.1	Monitoring using Assertions	29
4.2	Parameterised Properties	34
4.3	Conclusions	38
5	Aspect-Oriented Programming	41
5.1	The Basics of Aspect-Oriented Programming	42
5.1.1	Joinpoints and Pointcuts	42
5.1.2	Advice and Code Injection	43
5.1.3	Adding Attributes and Methods	44

5.2	Using AspectJ for Monitoring	44
5.3	Advanced AOP Considerations	50
5.4	Conclusions	51
6	Event Guarded Command Language	53
6.1	Introduction	53
6.2	Event Guarded Command Language: The Syntax	53
6.3	Compiling into AspectJ	56
6.4	Parameterised Properties in EGCL	59
6.5	Compiling Parameterised EGCL	62
6.6	Conclusions	65
7	Symbolic Automata	67
7.1	Automata for Monitoring	68
7.2	Symbolic Automata	70
7.3	Compiling Symbolic Automata	74
7.4	Parameterised Automata	81
7.5	Compiling Parameterised Automata	83
7.6	Conclusions	84
8	Regular Expressions	87
8.1	Regular Expressions	88
8.2	Monitoring Regular Expression Scripts	91
8.3	Verification of Monitoring Regular Expressions	94
8.3.1	Regular Expressions and Automata	94
8.3.2	Regular Expression Derivatives	97
8.4	Regular Expressions as Positive Specifications	102
8.5	Parameterised Regular Expression Monitoring	105
8.6	Conclusions	108
9	Linear Temporal Logic	109
9.1	Syntax and Semantics	109
9.2	Parsing LTL Formulae	113
9.3	LTL Runtime Verification	116
9.4	Parameterised LTL Formulae	120
9.5	Conclusions	122
10	Monitoring Real-Time Properties	123
10.1	Monitoring Real-Time Properties	124
10.2	Timers	125
10.3	Advanced Timer Features	127
10.4	Real-Time Issues	130
10.5	Conclusions	131

11	Reactive Runtime Monitoring	133
11.1	Runtime-Verification-Triggered Reparations	134
11.2	Runtime Enforcement	138
11.3	State Rollback through Checkpointing	143
11.4	State Rollback through Compensations	148
11.5	Monitor-Oriented Programming	151
11.6	Conclusions	153
12	Offline Runtime Verification	155
12.1	Logging of Events	156
12.2	Replaying Events for Monitoring	157
12.3	Dealing with System State	159
12.4	Asynchronous and Offline Verification: The Fine Print	161
12.5	Conclusions	163
13	Other Advanced Topics	165
13.1	Efficiency Considerations in Runtime Verification	165
13.1.1	Measuring Overheads	166
13.1.2	Measuring Time	168
13.1.3	Measuring Memory	169
13.1.4	Reducing Overheads	169
13.2	Persistent Runtime Monitors	174
13.3	Testing and Runtime Verification	176
13.4	Monitoring Architectures	179
13.4.1	Distributed FiTS	179
13.4.2	Specifying Distributed Properties	182
13.4.3	Distributing Runtime Verification	184
13.5	Conclusions	186
14	Conclusions	187
14.1	Runtime Verification Concerns	187
14.2	Adopting Runtime Verification in the Industry	189
	Further Reading	191
	References	197
	Index	203

Foreword

In all my many years of software development, I have never seen runtime verification done as part of the testing process and now I cannot see how you could test a software product without it.

R. T. Brownrigg

The above quote is an unedited snippet from an e-mail by Richard Thomas Brownrigg. Richard is a distinguished software developer and project leader with numerous decades of experience. He wrote the e-mail to his wife, directly after participating in a one-day tutorial about Runtime Verification given by one of the authors of this book. I quote the message here, with Richard's permission, because it represents very well two truths about the topic at hand. First, Runtime Verification is not yet a mainstream technique in software development practice (at the time of writing this foreword). Second, Runtime Verification, in particular in the incarnation that Colombo and Pace put forward here, is very accessible and convincing to software developers once they are exposed to it, offering huge benefits on relatively little costs.

I am convinced that this book will have a strong impact on spreading the usage of Runtime Verification in software practice, thereby contributing greatly to the quality of the development of software systems, and indeed to the safe operation after deployment. The reason for my conviction is not simply the potential of Runtime Verification as a technology. That also. But it is very much the particular approach and style Colombo and Pace take in this book. It is not meant to barely inform the reader about the topic, but to put the reader in the position to actively use Runtime Verification in development and deployment of real software. The reader is part of a very practical journey, through exercise-centric chapters, which provide step-by-step insights into the usage of the discussed concepts and techniques.

When reading this book, what amazed me most, however, is the approach Colombo and Pace take to learning. The best way to truly understand any concept is to first invest into solving problems *without* it. Only then, after having experienced the targeted challenges, the new concept is introduced, whereafter we can *experience the empowerment* that the introduced concept provides us with. The authors follow this philosophy quite strictly and carefully. Manual monitoring is exercised before aspect-oriented programming is introduced, allowing for a better separation of concerns, and higher automation when realising monitored systems. This is, again, exercised, before guarded command specifications are introduced, allowing to specify properties that are easier to write, read, and maintain than aspects. Once more, this is put into practice before the introduction of automata allows us to, more concisely, match the (graphical) intuition of a system manoeuvring through different modes of operation. The book moves on in exactly this way to further topics: regular expressions, temporal logic, real-time monitoring, reactive monitoring, and offline verification. Time and again, the course of the text and the accompanying exercises assure that every new plateau of the toolbox is explored practically, before the next plateau offers new solutions to the problems we have already experienced.

With that, I wish the reader a great journey, empowering you with a new way of developing and deploying robust software solutions.

Gothenburg
May 2022

Wolfgang Ahrendt

Preface

Runtime verification has been around for over 20 years, with a substantial body of literature and numerous tools available. In the couple of decades we have been working within the area of runtime verification, we have witnessed and contributed to the growth of the field: the theoretical underpinnings, new verification techniques, new instrumentation strategies, development of tools, and their application in industrial case studies.

The techniques refined over these past years feel ripe for adoption in industry and yet, while one can find various theoretical overviews and academic articles, a hands-on manual which guides the reader from zero knowledge to sufficient practical knowledge required to consider its use in industry is still sorely missing. Given how industry-friendly runtime verification is, lack of such a text is surprising and regretful.

This book aims to fill this void, starting with no assumptions on the knowledge of the reader and providing exercises throughout the book through which the reader builds their own runtime verification tool. All that is required are basic programming skills and a good working knowledge of the object-oriented paradigm, ideally Java.

The book does not aim to be an exhaustive overview of the area of runtime verification. Many important research questions are still the topic of active research and discoveries, but in this book we stick to the practical underlying principles and techniques. At the end of the book we touch upon a number of more specialised areas, such as the monitoring of distributed systems and real-time systems, but such advanced topics are beyond the scope of the book. Furthermore, although we cover the pragmatic side of runtime verification, we do not delve into the theoretical foundations. However, for each chapter we do provide a reading list in the appendix for the interested reader who would like to deepen their knowledge in a particular area.

Reading guide: The first six chapters of the book should be read in order and are prerequisites for all the others that follow. Chapters 7–10 can be read independently, since each look into the use of different specification language

requirements: whether automata, regular expressions, linear time temporal logic, or real-time properties. Similarly, Chapters 11–13 are largely independent, focusing on the practical implications of runtime verification: Chapters 11 and 12 are duals of each other on the spectrum of monitor intrusiveness, while Chapter 13 gives a brief overview of a number of more advanced topics, ranging from concerns of efficiency and persistence, to integration with testing and architectural considerations.

Christian Colombo
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