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Ezio Bartocci · Rance Cleaveland ·  
Radu Grosu · Oleg Sokolsky (Eds.)

# From Reactive Systems to Cyber-Physical Systems


Essays Dedicated to Scott A. Smolka  
on the Occasion of His 65th Birthday

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ISSN 0302-9743

ISSN 1611-3349 (electronic)

Lecture Notes in Computer Science

ISBN 978-3-030-31513-9

ISBN 978-3-030-31514-6 (eBook)

<https://doi.org/10.1007/978-3-030-31514-6>

LNCS Sublibrary: SL1 – Theoretical Computer Science and General Issues

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**Scott A. Smolka**

Courtesy of Computer Science Department, Stony Brook University, USA.  
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# Preface

This Festschrift is dedicated to Scott A. Smolka on the occasion of his 65th birthday that was celebrated on August 1, 2019. This book contains the papers written by his closest friends and collaborators. These papers were presented during a two-day workshop organized in his honor that was held during August 1–2, 2019, at Stony Brook University, NY, USA.

Scott joined the Department of Computer Science of Stony Brook University in 1982, and was promoted to full professor in 1995. In 2016 he was appointed to the rank of Distinguished Professor in the same university.

He has made fundamental research contributions in a number of areas, including process algebra, model checking, probabilistic processes, runtime verification, and the modeling and analysis of cardiac cells and neural circuits. He is perhaps best known for the algorithm he and Paris Kanellakis invented for checking bisimulation. Scott's research in these areas has resulted in over 200 publications, generating more than 9,000 citations.

He has been principal investigator and co-principal investigator on grants totaling more than \$23 million, and he is the lead principal investigator of CyberCardia, a \$4.3-million National Science Foundation (NSF) multi-institutional grant, "Compositional, Approximate, and Quantitative Reasoning for Medical Cyber-Physical Systems." He served as Deputy Director of a \$10-million NSF multi-institutional grant on "Computational Modeling and Analysis of Complex Systems." Scott is also a director and co-founder of Reactive Systems, Inc., a company selling tools and services for embedded-software testing and validation.

In 2016, Scott was recognized as a Fellow of the European Association for Theoretical Computer Science for his "fundamental contributions in formal modeling and analysis." He is the recipient of the President and Chancellor's Award for Excellence in Scholarship and Creative Activities, and the Department of Computer Science's Research Excellence Award.

The title of this volume, *From Reactive Systems to Cyber-Physical Systems*, reflects Scott's main research focus throughout his career. The contributions, which went through a peer-review process, cover a wide spectrum of the topics related to Scott's research scientific interests, including model repair for probabilistic systems, runtime verification, model checking, cardiac dynamics simulation, and machine learning.

Dear Scott, on behalf of all your friends, students, and collaborators, we wish you all the best!

June 2019

Ezio Bartocci  
Rance Cleaveland  
Radu Grosu  
Oleg Sokolsky



**CyberCardia Team**

Courtesy of Rahul Mangharam, University of Pennsylvania, USA.  
Used with permission.



## Personal Notes for Scott

**From Ezio Bartocci** - I met Scott for the first time twelve years ago, while I was pursuing my PhD in Italy. My former advisor, given my background in both computer science and biology, suggested me to spend three months in Stony Brook to visit Scott. During that period, Scott and Radu were working on computational modelling and analysis of cardiac dynamics. Starting that collaboration was of key importance to my life, with a clear impact on my future academic career - and not only. Scott has been a wonderful teacher, nurturing motivation, ideas and new exciting problems to be solved, beyond my stay in Stony Brook. I am extremely indebted to Scott. I consider him not only a scientific father, but also a dear friend and I am very happy to organize this event.

Scott I wish you all the best for your 65th birthday!!

**From Samir Das, Chair of the Department of Computer Science, Stony Brook University** - Scott is a leading expert in formal methods for the analysis of computing systems and has an outstanding track record for making foundational technical contributions and applications to real-world problems. He is inspiring to both our faculty and students. His visibility and high-impact research bring significant recognition to our department.

**From James Glimm** - Congratulations Scott! I have learned so much from the CyberCardia project and benefited from your leadership of it. I have met with many new colleagues and renewed an ancient collaboration with Flavio Fenton. You have made all of this possible. My deepest thanks for this.

**From Radu Grosu** - It is my great pleasure and honor to write a Laudation for Scott Smolka with the occasion of his 65-birthday celebration, highlighting some of my memories with him. Scott has become over the years not only a mentor but also a true friend of mine.

In order to do justice to my recollections with Scott, I would have to write volumes. The first would be about our countless hours of joint research, which are continuing to this day. The second would be about our common passion for tennis, and the countless hours spent together on the tennis courts. The third would be about our countless dinners together, where we both enjoyed wonderful conversations and delicious food. Finally, the fourth would have to be about the miraculous way he overcame a serious illness, such that we still have the privilege to be with him today. Since I will not have the space required for these volumes, I will just mention the way I would probably like to start the first volume.

One of the most distinguished aspects of Scott's work is his extraordinary ability to identify very relevant and exciting research problems, by giving an often-unexpected twist to a mainstream research topic. One of the problems he came up with happened

during the time I still was in Stony Brook. Together with our systems colleague, Erez Zadok, we were looking at various verification problems for the Linux OS. As we soon realized that scaling up model checking to the extensive Linux-OS code was still problematic, we started to consider cheaper and faster ways to achieving results. Runtime verification (RV) seemed to be the right way to go, as it allowed us to regard the OS as a black box. However, we needed to instrument the code with monitors, which introduced in some cases considerable overhead. While looking for ways to reduce this overhead, by selectively enabling and disabling some of the monitors, Scott spent a sabbatical at NASA JPL working together with Klaus Havelund. When he came back, he posed us the following research problem: What happens to RV if one misses observations? This problem took us by surprise, but we immediately realized its importance. Formalizing observation uncertainty required either the use of nondeterminism, leading to a logical approach to the problem, or probabilities, leading to a stochastic approach. Since in the former one learns pretty large automata models (and thus monitors), we opted for the latter, and at the suggestion of Scott Stoller, we settled to Hidden Markov Models (HMM). During our discussions, I realized that Scott's problem, was strongly related to the state-estimation problem in control theory and we dubbed our paper as "Runtime Verification with State Estimation". Ezio Bartocci, a Post-doctoral student at that time, took over the implementation aspects, by using the Baum-Welch algorithm to learn the appropriate HMMs from corresponding partial traces. This allowed us to successfully compute the probability that a desired property of a system was violated or not during blackout periods, that is, while the systems was running without being observed. Our synergistic work resulted in a paper that was later distinguished with the best paper award at the RV'11 conference. Scott triggered it all.

Another scientific problem posed by Scott using his above-mentioned ability is Flocking in V-Formation. We are still working on it today. It touches even more aspects of (possibly distributed) machine learning, verification, and control. The origins of this work have a very interesting story, too, but I leave this for another occasion.

**From Panagiotis Katsaros** - On the occasion of celebrating the 65th birthday of Scott Smolka I would like to express my best wishes, along with my joy for having the honour to collaborate with Scott during the last decade of his amazing research career. Many colleagues will remind Scott's seminal contributions in an impressively wide range of research problems on formal modeling and verification. I will recall the man who always leads his group to pioneering research ideas, the man with the strength to collaborate with his fellows from the beginning to the last moment of a research by overcoming any durability limitations, the man who inspires the younger researchers with his attitude and human potential, our good friend, our own Scott. Happy birthday Scott! I wish having the chance to work with you for many more years yet.

**From Shan Lin** - Dear Scott, I really appreciate all your help for me to start my research career at Stony Brook. You've always been there, providing guidance and advise since I joined Stony Brook. You have inspired me to work on my new projects and explore new directions. I am very grateful for your support and looking forward to continuing to work together.

**From Emanuela Merelli** - When I met Scott for the first time, it was at Sunny. We went for a meeting; during my talk about BioAgent modeling, Scott asked me if the behavior of an agent in the multi-agent system was deterministic and how to analyze the evident non-deterministic behavior emerging from the interactions of biological entities whose compositional rules are unknown. He was speaking with his long vision about of Aristotle's "the whole cannot be decomposed as the sum of its parts". Many years passed, I'm happy to take this opportunity to thank Scott for helping me foster a critical sense in going towards new intriguing science for Computer Science. It is unbelievable how a person, even if met for some hours, can change your mind; this is my experience in meeting Scott. For these reasons, I'm honored to take part in Scott's Festschrift contribution.

**From Oleg** - I arrived at Stony Brook for my Ph.D. studies without, as it quickly turned out, a reasonable understanding of how computer science research works or even what computer science, as a discipline, is about. Running into Scott at one of the department's Friday donut hours during my first semester turned out to be my lucky break, which helped me find direction both in my doctoral work and later in my career. He encouraged me to attend group meetings to learn more about the topic and later invited me to join the group.

I had a lot of fun working a number of challenging problems while at Stony Brook and learned much about formal verification. Still, probably the most important things I learned were the ones you cannot pick up from technical papers. Scott was very generous with sharing his insights into what it means to do good research, how to choose problems to attack, and how to derive pleasure from solving them.

I would like to share a memory, which at the time has significantly influenced my decision to stay in academia after completing my Ph.D. We had a weekly project meeting that involved Scott, Gene Stark, and several of their students, including myself. One day I showed up for the meeting, expecting students to give the usual progress reports, followed by guidance from professors. Instead, Scott came in a very bright mood and said that he had proved a new result and wanted to share it with the group. The lively discussion that followed showed me that, first, it is possible to make good technical progress without relying on graduate students. And second, maybe even more importantly, I saw how excited Scott was and how much he enjoyed doing it. I clearly remember thinking: if this is really as much fun as it seems, I want it, too. I did stick with academic research and never regretted it. Thanks, Scott, for setting me (and your many other students) on the right track!

**From Shoji Yuen, Nagoya University, Japan** - Dear Scott, Congratulations on your 65th birthday!! In Japanese, "65-sai no Otanjobi, Omedetou-Gozaimasu". It's been a long time since my last visit to Stony Brook. I cannot believe how fast time passed and how quickly things have been changing. Because of your great help and kindness, I have been able to stay in academia till now. I do wish you stay well and take good care of yourself. Hope you visit Japan again.

**From Erez Zadok, Professor and Graduate Academic Adviser** - In my PhD work I had to write and debug lots of difficult kernel code. When I joined the department in 2001, I found out that Scott worked on verification. Knowing very little about verification, I approached Scott with a “simple” request that I hoped would ease my work—to verify all five million or so lines of Linux kernel code. Scott smiled, took a deep breath, and carefully explained to me why this task is “not as simple” as I had thought, especially for complex operating system code written in C. Boy, that was an understatement! Knowing what I know now, Scott could have easily burst in laughter at my naiveté. Instead, we began to collaborate towards that goal—a highly fruitful and rewarding collaboration that continues to this day. Here’s hoping for many more years of learning from Scott’s wisdom.

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