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Guest Editorial: Special issue on formal modeling and analysis of timed systems

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The importance of modeling, design, and verification of systems has been further emphasized by the rise of ubiquitous and autonomous computing. As a result, the need for precise and scalable approaches that can treat a variety of embedded and cyber-physical systems with the rich temporal dynamics of their environment is keenly felt for a variety of application domains including home appliances, autonomous vehicles, and medical devices. The international conference on Formal Modeling and Analysis of Timed Systems (FORMATS) brings together researchers from different disciplines to promote the study of fundamental and practical aspects of systems governed by combinations of logical and temporal constraints.

In 2015, the 13th edition of FORMATS was held in Madrid, Spain, where an interesting and diverse program was presented, with topics including: the theoretical foundations of timed systems; analysis algorithms and software tools; and applications to a variety of problem domains wherein timing plays a crucial role, such as cyber security, scheduling, and power management. Selected papers were invited to submit extended journal versions for this special issue of the Real-Time Systems Journal. In

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all, we received three submissions that are presented in this issue after rigorous peer review by experts from the areas of real-time systems and formal verification. This issue presents a sample of methods and approaches for the analysis of timed systems from the research community of FORMATS.

The first work, by Florian Lorber, Amnon Rosenmann, Dejan Ničković, and Bernhard Aichernig, presents efficient algorithms to determinize timed automata with silent transitions when the length of execution traces is bounded. The authors illustrate how the approach can be applied to *model-based mutation testing*, a test-case generation method which requires deterministic models; an industrial case study motivates the example in the area of embedded systems.

The second work, by Patricia Bouyer, Nicolas Markey, Nicolas Perrin, and Philipp Schlehuber-Caissier, presents a new abstraction to encode safe trajectories of switched dynamical systems as timed automata. This approach enables the use of verification methods and controller synthesis *in continuous time*, without the need to discretize system evolution over time. Using this abstraction, reactive control problems, such as reaching a set of goal states while avoiding illegal ones, can be solved as *games* on timed automata, with practical applications in the area of safety-critical and cyber-physical systems.

The third work, by Gethin Norman, David Parker, and Xueyi Zou, presents verification and control techniques for *probabilistic* systems where the current state is only *partially observable*. Based on the history of available observations, a strategy is synthesized to decide which actions to take in order to maximize a reward in an environment governed by temporal constraints and probability. Discrete-time solutions are applied to continuous-time problems by careful analysis of conditions that preserve system properties after discretization, in order to prove the correctness of the approach. Notable applications are in the area of artificial intelligence and planning, and case studies are presented for wireless network scheduling, secure communication, and non-repudiation protocols.

Together, these works offer an overview of current research trends in formal methods for the analysis of timed systems. We hope that the readers of the Real-Time Systems Journal will find this special issue useful and inspiring, and that it will foster fruitful collaborations and exchange of research insights.