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**Abstract of the PhD Thesis:  
On the Verification of Parametric and  
Real-Time Systems**

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## Abstract

Parametric and Real-Time Systems play a central role in the theory underlying the *Verification* and *Synthesis* problems.

Real-time systems are present everywhere and are used in safety critical applications, such as flight controllers. Failures in such systems can be very expensive and even life threatening and, moreover, they are quite hard to design and verify. For these reasons, the development of formal methods for the modeling and analysis of safety-critical systems is an active area of computer science research.

The standard formalism used to specify the wished behaviour of a real-time system is *temporal logic*. Traditional temporal logics, such as linear temporal logic (LTL), allow only qualitative assertions about the temporal ordering of events. However, in several circumstances, for assessing the efficiency of the system being modeled, it may be useful to have additional quantitative guarantees. An extension of LTL with a real-time semantics is given by the *Metric Interval Temporal Logic* (MITL), where changes of truth values happen according to a splitting of the line of non-negative reals into intervals.

However, even with quantitative temporal logics, we would actually like to find out what quantitative bounds can be placed on the logic operators.

In this thesis we face with the above problem proposing a parametric extension of MITL, that is the *parametric metric interval temporal logic* (PMITL), which allows to introduce parameters within intervals. For this logic, we study decision problems which are the analogous of satisfiability, validity and model-checking problems for non-parametric temporal logic. PMITL turns out to be decidable and we show that, when parameter valuations give only non-singular sets, the considered problems are all

decidable, EXPSpace-complete, and have the same complexity as in MITL. Moreover, we investigate the computational complexity of these problems for natural fragments of PMITL, and show that in meaningful fragments of the logic they are PSPACE-complete.

We also consider a remarkable problem expressed by queries where the values that each parameter may assume are either existentially or universally quantified. We solve this problem in several cases and we propose an algorithm in EXPSpace.

Another interesting application of the temporal logic is when it is used to express specification of concurrent programs, where programs and properties are formalized as regular languages of infinite words. In this case, the verification problem (whether the program satisfies the specification) corresponds to solve the language inclusion problem.

In the second part of this thesis we consider the Synthesis problem for real-time systems, investigating the applicability of automata constructions that avoid determinization for solving the language inclusion problem and the realizability problem for real-time logics. Since Safra's determinization procedure is difficult to implement, we present Safraless algorithms for automata on infinite timed words.