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Delays, Clocks, Timing and Reliability in Networked Control Systems: Theories, Protocols and Implementation

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For the purpose of verification of safety properties, a networked control system can sometimes be viewed as a hybrid system, which consists of a discrete state transition system representing the dynamical behavior of computational entities, and differential equations describing the continuous dynamics of physical entities. Once a networked control system is so modeled as a hybrid system model, its safety verification can typically be addressed through a reachable set computation of the hybrid system. However, computing the reachable set of a hybrid system is a non-trivial problem in general due to the complex interaction between dynamics in two different domains. In fact, even for a hybrid system whose continuous dynamics is linear, deterministic, and time-invariant, it is not known that computation of its reachable set is a decidable problem.

In this project, we study this problem, making progress by identifying a framework that is both tractable, and which constitutes a model class that is useful for several applications. More precisely, we show that it is possible to compute an over-approximation of a reachable set for a class of hybrid automata, which we call Deterministic Transversal Linear Hybrid Automaton (DTLHA), for a finite time, with arbitrarily small approximation error, even though computing the exact reachable set for such a hybrid automata is still not computationally feasible. Moreover, we also show that such an over-approximation can still be computed even without requiring infinite precision calculations of the underlying numerical operations. A software architecture is also proposed for the implementation of a software tool to compute a reachable set of a DTLHA. It is designed to decouple the basic algorithm, proposed based on our theoretical framework, from the choice of several runtime adaptations that are needed by the basic algorithm to continue its computation.

References

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