Temporal Logics for Real-Time System Specification

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The specification of reactive and real-time systems must be supported by formal, mathematically-founded methods in order to be satisfactory and reliable. Temporal logics have been used to this end for several years. Temporal logics allow the specification of system behavior in terms of logical formulas, including temporal constraints, events, and the relationships between the two. In the last ten years, temporal logics have reached a high degree of expressiveness. Most of the temporal logics proposed in the last few years can be used for specifying reactive systems, although not all are suitable for specifying real-time systems. In this paper we present a series of criteria for assessing the capabilities of temporal logics for the specification, validation, and verification of real-time systems. Among the criteria are the logic's expressiveness, the logic's order, presence of a metric for time, the type of temporal operators, the fundamental time entity, and the structure of time. We examine a selection of temporal logics proposed in the literature. To make the comparison clearer, a set of typical specifications is identified and used with most of the temporal logics considered, thus presenting the reader with a number of real examples.

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1. INTRODUCTION

During the last few years, several techniques, tools, and models for the formal specification of real-time systems have been proposed. Typical applications can be found in avionics, robotics, process control, and healthcare. For real-time applications, the meeting of temporal constraints are mandatory. A system specification must formalize system behavior (including temporal constraints), and thus the model must be supported by mechanisms that verify conformity with requirements. Behavior is typically expressed by giving a set of relationships enumerating the temporal constraints among events and actions, such

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