Real-time test specification with TTCN-3*

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Abstract. In this paper we propose an extension to the third edition of the Tree and Tabular Combined Notation (TTCN-3) to support real-time testing. Our approach is based on the separation of functional and real-time requirements in the test specification. Functional requirements are defined in form of stimuli and expected responses, i.e., in form of functional TTCN-3 test cases, and real-time requirements are expressed by the relationship of points in time. During test execution the points in time are collected in form of time-stamps that can be evaluated during or after the test run. We explain all extensions to TTCN-3 necessary to support the collection and evaluation of time-stamps and show the applicability of our approach by means of an example.

Motivation

Testing (e.g. [1, 6, 7]) is an important issue during the development processes of communication systems and can be divided into two categories: testing of functional and non-functional requirements. An important sub-category of non-functional requirements are hard real-time requirements [2, 8].

Functional testing is well studied and there exists a standardized testing language: TTCN-3 [3, 4]. Real-time testing is still under study. There is no standardized language to specify real-time tests.

In this paper, we present an extension for TTCN-3 in order to use it for real-time testing. Our intention is to present a powerful but easy to use language extension without changing the existing TTCN-3 semantics. We concentrate on the formal test specification of hard real-time requirements, but not on the theoretical foundations of real-time testing. Our approach aims at the specification of hard real-time requirements, such as delay, response time, latency, throughput, jitter etc.

A solution for Real-Time Testing

The main idea is to separate the description of functional and hard real-time requirements. This allows a clear distinction between these two classes of properties.

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The essence of the various real-time requirements can be broken down to the relationship of pairs or tuples of time-stamps. Hence, our description of real-time requirements is based on relating particular points in time to each other. By using mathematical equations, constraints on those time points can be imposed.

In order to obtain such time-stamps, a functional test case has to be instrumented with special log statements. Thus, during test case execution, time-stamps of the relevant events are recorded.

The analysis whether the recorded time-stamps met the real-time requirement can be done either off-line when test execution has finished or on-line during the test run. Off-line evaluation has the advantage of delaying the test execution by just a small amount of time which is needed for time-stamping. However, in certain situations, functional and non-functional behavior may influence each other. Therefore, an on-line evaluation during the test run might be necessary, too. In this case, time needed for evaluation is critical, because it slows down the tester and influences test execution and verdict.

Implementation using TTCN-3

In order to get time-stamps of the interesting events, the TTCN-3 test cases have to be instrumented by log statements which writes time-stamps in a log file. In TTCN-3, a log file may contain information about sending and receiving events including time information. By evaluating the log file with respect to the time-stamps, compliance to real-time requirements can be checked. Related log entries can be identified and be used as input for the evaluation programs that check the real-time requirements.

The evaluation programs have to be specified in a machine processable format. Since we are already in the TTCN-3 domain, it is obvious to express them by using TTCN-3 functions. Depending on whether a real-time property described by a TTCN-3 evaluation function holds for a test case or not, a verdict can be assigned.

Off-line evaluation can be done independently from the execution of a test case. In this case, no modifications to the TTCN-3 language are needed. A shell script could for instance be used to analyse the log file and feed the extracted time-stamps into the evaluation functions. For on-line evaluation, an extensions of the TTCN-3 language is necessary. Means to interleave test execution and test evaluation have to be added in order to allow such a reactive testing.

Case study

As a case study, we chose the INRES protocol [5] to assess our approach. We enhanced INRES with real-time requirements. The functional TTCN-3 test suite was instrumented by log statements in order to get a log file which can be analysed.

In simple cases, it is just necessary to search for the time-stamp keyword and the additional label within the log file in order to get the time of a certain

event. Slightly more complex cases evolve when loops are executed. In this case, the same label will occur several times in the log file. Nevertheless, using the knowledge of the order of the log statements in the test specification allows to find the right tuples of time-stamps.

This simple approach is not possible anymore if e.g. signals can get lost. A simple pattern matching scheme to find adjacent tuples of time-stamps cannot be applied. However, additional information, like package numbers or consecutive numbers which are coded as arbitrary data in available signal data fields, could be utilised to identify matching tuples of time-stamps.

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