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ACCELERATED STRESS TESTING OF CONTROL SYSTEMS

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Abstract: *The main goal of article is the automation possibility of accelerated stress testing. The proposal is focused into control systems as a part of Information systems. The contribution demonstrates the usage of Step Stress Test in the fully automated test system, using minimum of human intervention. Our proposal captures the particular states which occur in the test system. Our proposal has been visualized in UML diagrams.*
Key words: *stress testing, automation, control system, UML*

1. INTRODUCTION

Testing as part of verification and validation is very important process. It belongs to one of the most important phases of life cycle and each system must be tested. One of the most important types of the testing are accelerated stress tests that are part of the accelerated testing.
Each accelerated testing is an approach for obtaining more information from a given test time than would normally be possible. It does this by using a test environment that is more severe than that experienced during normal equipment use. Since higher stresses are used, accelerated testing must be approached with caution to avoid introducing failure modes that will not be encountered in normal use. (Paulicek et al., 2008)

1.1 Accelerated Stress Testing

Uses accelerated environmental stresses to precipitate latent defects or design weaknesses into actual failures to identify design, part or manufacturing process problems which could cause subsequent failures in the field. Requires a thorough understanding, or at least a workable knowledge, of the basic failure mechanisms. Estimation of item life may, or may not, be a concern.(Criscimagna, 2010)
Accelerated test models relate the failure rate or the life of a component to a given stress such that measurements taken during accelerated testing can then be extrapolated back to the expected performance under normal operating conditions. The implicit working assumption here is that the stress will not change the shape of the failure distribution.
Documenting the rationale for these choices is important. (Criscimagna, 2010) There are several Accelerated Test Models, to the most common we can include:

Inverse Power Law
The inverse power law relationship (or IPL) is commonly used for analyzing data for which the accelerated stress is nonthermal in nature. (Vassiliou & Mettas, 2003) The inverse power law (IPL) model is given by,

(1)

where:
- L represents a quantifiable life measure, such as mean life, characteristic life, median life, B(x) life, etc.
- V represents the stress level.
- K is a model parameter to be determined, (K > 0).
- n is another model parameter to be determined.

Arrhenius Acceleration Model
The Arrhenius relationship is commonly used for analyzing data for which temperature is the accelerated stress. (Vassiliou & Mettas, 2003) The Arrhenius model is given by,

(2)

where:
- L represents a quantifiable life measure, such as mean life, characteristic life, median life, or B(x) life, etc.
- V represents the stress level (in absolute units if it is temperature).
- C is a model parameter to be determined, (C > 0).
- B is another model parameter to be determined.

Miner's Rule (Fatigue Damage)
The fatigue damage model is given by,

(3)

where:
- CD = cumulative range
- C_{Si} = number of cycles applied at a given mean stress Si
- N_i = the number of cycles to failure under stress Si, (as determined from an S-N diagram for that specific material)
- k = the number of loads applied

This model assumes every part has a finite useful fatigue life and every cycle uses up a small portion of that life. Failure is likely to occur when the summation of incremental damage from each load equals unity. Miner's rule does not extend to infinity, however. It is valid only up to the yield strength of the material; beyond that point it is no longer valid. (Criscimagna, 2010)

2. PROPOSAL OF ACCELERATED STRESS TESTING

The design of our accelerated stress test model is based on our previous proposal, which is described in our earlier research work. (Špendla et al., 2010). The starting point for our previous proposal is the IEEE 829 testing methodology. Its individual phases were modified with the basic steps of automated software testing. They were mapped and captured in the UML Sequence diagram. This diagram allows cleaner and simpler description of testing steps from the time aspect. (Jedlicka et al., 2008) In Fig. 1 our model of basic step stress test proposal is captured. This proposal is modeled as an UML Activity diagram with a certain degree of abstraction. It captures the initialization and iterations of step stress test. It should be noted that this diagram includes simple, but also complex activities. The test is brought to the end, if in the iteration are more than 50% of failed parts, or even if there is at least one failed part in a fully censored test. The next consequent part of our proposal is focused on the state description that may occur in our modified step stress testing process. A set of states is captured as a synchronous sequence. This is mainly due to the complexity and clarity over asynchronous model. Because of

the degree of abstraction of our model, we have not captured and described internal actions and activities in individual states.

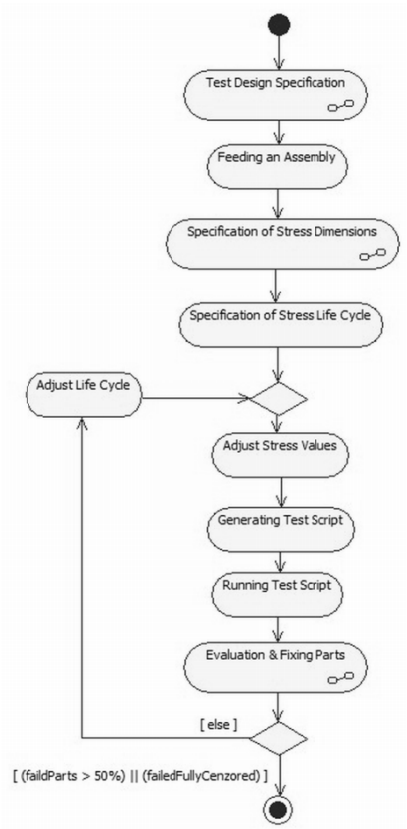

Fig. 1. The fundamental proposal of modified phases of step stress test

The result of our proposal is UML State machine diagram, which is captured in Fig. 2. A set of previous standard states, according to standard IEEE 829 is captured as initial state, named PreviousStandardStates. This complex state occurs as the first state in our proposed testing process. When the event gainedSpecificationOfRelevantData occurs, testing process passes to the state Sampling, where the input action is invoked. The role of this action is to describe the parts to be tested. The state has also the task of filling the test sample, repairing the broken parts, etc. At signalizing the output event, the output activity occurs moving the sample of the tested parts to actual iteration of the test.

By the event TestSampleReady the process passes into the state TestParameterSpecification. The role of the input action is to identify the iteration in which the testing process is present. This is mainly because of identification of the initial fully censored test. Some of the internal actions of this state are the life cycle adjustment, stress values adjustment and initial stress dimension specification. The task of the output action is the verification of the changed values in this test iteration. This event occurs after the innovation of adjustedValues action that moves the process to TestProcedureDefinition state.

After reaching this state, the loadPreviousTestScript action is executed. Previous test script is loaded for its further modification in this iteration. This state is specific, inter alia, by the generating of the test script to be loaded and carried out in the state TestExecution after sending a message on the generated test script. It should be noted that as an output action the verification of the generated test script must be carried out.

It should also be noted that this state TestExecution is a combination of the two document types of the IEEE 829 testing methodology. The main task of the output action is to store the data obtained from the test script.

After receiving the test results, which represent the output event, test proceeds to TestSummary state. This state with the input action gains data from the current iteration. This state also brings together all important information about current iteration of the test and records it for the later whole test summary. The result is a test log, which is also a part of the output action.

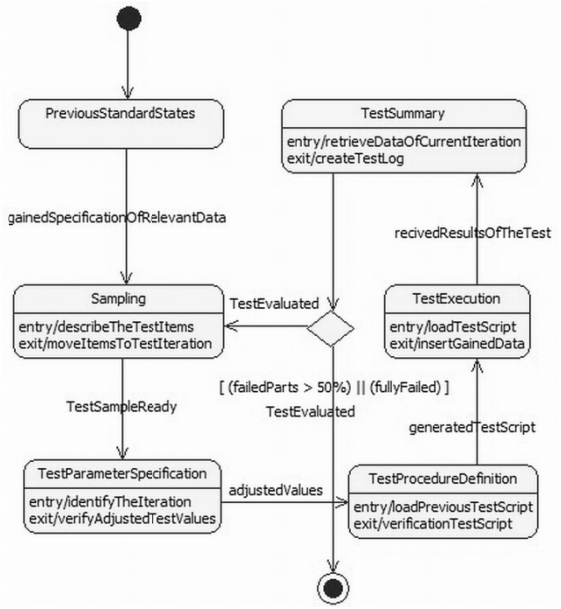

Fig. 2. Global State machine diagram

The event that initiates the next iteration of the test is Test Evaluated. The whole process repeats until more than 50% of the parts from the test sample fail or if in the fully censored test iteration a failure occurred. These conditions are based on standard methods of the step stress testing.

3. CONCLUSION

The aim of this article is to design automation of accelerated stress testing for control systems. Our proposal is based on the modified basic steps of automated software testing. As a type of accelerated stress testing, we chose the step stress testing to use. Our design was captured by Activity diagram and State machine diagram in UML 2.0.

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