Increasing Product Quality by Verification and Validation Improvements in an Industrial Setting

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Abstract

Large and complex software systems are developed as a tremendous engineering effort. The aim of the development is to satisfy the customer by delivering the right product, with the right quality, and on time. Errors made by engineers will always occur when a system is developed, but their number can be decreased by process improvement and their effect can be reduced by removing them as early as possible.

The research is performed at Ericsson Microwave Systems AB and the thesis consists of six papers.

The thesis concentrates on how to increase product quality and reduce lead-time, by improving the verification and validation processes and methods.

1. Research Questions

The main research question, which has been the basis for this thesis is “How should system verification and validation be conducted for large software systems to achieve high quality at a low cost?” Since system verification and validation activities involve a great number of processes and techniques, the research must be limited. The important issues for the organization have influenced the limitations. The important issues have for example involved verification and validation process improvements, finding expensive faults early, and reducing the cost of expensive system tests. The research has also involved how the verification and validation process can be evaluated for large software projects, for example, which measures should be used. The research questions are divided into process related and technique related questions. The process related questions deal with improving the verification and validation process in order to achieve high quality at a low cost. The technique related questions deal with specific verification techniques for finding faults early and reducing expensive performance validation tests. The research questions are summarized in Table 1.

Table 1. Research questions

<table>
<thead>
<tr>
<th>Type of question</th>
<th>Research question</th>
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<tbody>
<tr>
<td>RQ1 Process</td>
<td>What is the trade-off between inspections and testing in a software project, in terms of faults found and resources used?</td>
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<tr>
<td>RQ2 Process</td>
<td>What are the important characteristics of the verification and validation activities in the software development process in an organization?</td>
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<td>RQ3 Process</td>
<td>How can the effect of a change of the current verification and validation process be predicted?</td>
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<tr>
<td>RQ4 Technique</td>
<td>How can the reviews of requirements specifications be performed effectively and efficiently?</td>
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<tr>
<td>RQ5 Technique</td>
<td>How can system performance validation be performed efficiently?</td>
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2. Research Contribution

System verification and validation activities are often performed with methods that the engineers find most appropriate on a subjective basis. The knowledge of the difference in efficiency and effectiveness between different testing methods is often limited. The change from the current way of performing a certain task to a new is often done with an ad hoc assumption that the new way will improve the activity. The research presented in this thesis is a contribution to increase the knowledge of how the efficiency and effectiveness of verification methods can be evaluated and compared.

The research performed is also a contribution to the understanding on how improvement work can be
started in industrial organizations. Much work in industry is based on the engineering method, where new methods are implemented without a quantitative understanding of the current status. Furthermore, it is seldom known whether the new method is better or not. Even if the new method appears better, the improvement cannot be expressed in measurable terms. By studying how improvement work can be initiated in software organizations, the knowledge gained can help more organizations improve their development in a more systematic and controlled way. Furthermore, for a software project, it is not only important to know which inspection or test method that is best to use, it is also important to know the trade-off between the fault finding techniques. Paper I [1] deals with how measurements can be performed in the various testing activities in an organization.

The software industry is characterized by short lead times and limited resources. The implementation of a process change that will decrease the efficiency or effectiveness can be devastating for the organization. By estimating how the change will affect the development process, this risk is reduced. This means that organizations easier can improve their processes with a higher confidence that it will be a success. By using simulation models process changes can be predicted and thus reducing the risk. Paper II [2] is a contribution to this research.

System verification and validation activities are parts of the whole development process. It is therefore important to understand the characteristics of the V&V activities and the dependencies with other project activities in order to implement appropriate process improvements. In paper III [3] such a characterization is performed.

A requirements specification with few defects is essential for the verification and validation work, since the faults are often propagated into the design and code. A comparison between a passive and an active review method is presented in paper IV [4].

There is a lack, in industry and in the software research community, of efficient and effective system performance validation methods. This is an important area since the cost of system performance validation often is high. The currently used methods in industry are of the engineering type, which means the engineers use the methods they find most appropriate. Papers V [5] and VI [6] introduce a new performance validation method based on the well-known technique of factorial designs. The method has been extensively used in other research disciplines, but never in performance validation.

The main research contributions are:

- It is presented how measurements can be performed in the various testing activities in an organization. A measure of goodness is introduced, which measures whether faults could have been found earlier in the process.
- It is shown how a template simulation model can be adapted and extended to fit an organization in order to estimate how a change will affect the development process.
- The important characteristics of the verification and validation activities and the dependencies to other project activities in an organization are investigated in order to introduce process improvements. It is shown that interviews are a feasible means for the characterization.
- Two different review methods are compared. The comparison shows that an active review method is more efficient and effective than a passive one.
- The factorial design methodology is introduced as a method in system performance evaluation. The results show that a validation method, based on factorial design, is efficient when few factors are involved, and that prototyping and validation methods, based on fractional factorial designs, are efficient when many factors are involved.

3. References