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A Meta-Model for Risk-Based Testing Technique Based On the MDA Approach

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Abstract— In software testing area, risk-based testing is a testing technique that uses risk to prioritize and emphasize the appropriate tests during all phases of the test process. By using this technique we can organize testing efforts in a way that reduces the residual level of system risk when it is deployed. From the fact to its high practical relevance, several approaches that support Risk-Based testing technique have been proposed in academic and industrial research. Although, most of these approaches share common principal, common challenges and common characteristic that are inherited from the fundamental concepts of Risk-Based testing technique. In this context, we apply MDA approach to propose in this paper a generic Meta model that represents risk-based-testing elements, concepts, and relationships in order to define the structure and entities that must take any risk-based-testing approach.

Index Terms— Meta-Model, MDA, System Risk, Risk-Based-Testing, Software Testing, Testing Technique.

1 INTRODUCTION

IN view of the increasing complexity of information systems, which leads to an increase in the probability of occurrence of errors in a computer development project, it is necessary to follow a life cycle of the system in which the activities related to the system are increasingly important: the development of the system on the one hand and the testing activities on the other part.

Software testing is a set of activities that allows detecting defects in software systems in order to ensure a level of quality defined in agreement with the customer. Of its importance, this field has undergone a major evolution in academic and industrial research. New techniques, new paradigms, new tools and new approaches in this field show up in recent years to overcome some testing challenges and limits.

Risk-based testing (RBT) is one of the proposed testing techniques that aim to focus on the part of the system that requires most attention. It is a prioritization technique that allow to do the best possible with limited times and resources.

In this sense, several approaches and studies have been proposed within the scope of RBT, including a study that was done by Felderer and Schieferdecker[14]. This study was provided in order to presents taxonomy of risk-based testing. This taxonomy contains the top-level classes; risk drivers, risk assessment and risk-based test process and is aligned with the consideration of risks in all phases of the test process.

In the same scope, a new risk based testing approach for stress testing of critical non nuclear infrastructures is proposed by S. Esposito et al, through their paper [15]. The proposed methodology is named ST@STREST. It has been developed in the scope of the STREST project in order to assess the performance of individual components and the whole system with respect to extreme events, and to compare this response to acceptable values that are specified at the beginning of the stress test.

Most of the RBT approaches proposed in academic and industrial research have the common aspects and differ on several important points. we propose through this article a meta-model that allows the characterization of different risk-based testing approaches and that illustrate the common concepts of RBT approaches in addition to allowing validating any proposed approach. The rest of this paper is organized as follows: section II provides a literature of meta-model and risk based testing technique. Section III presents a description of risk based testing technique. Section IV, describes relationships between risk based testing elements in project management. Section V, describes the proposed meta-model for risk-based-testing technique. And finally, Sections VI and VII describe discussion, conclusion and future work.

2 RELATED WORK

The Meta-modeling is the activity that serves to construct meta-models. A meta-model is a definition of the structure that must take every model in conformity with this meta-model, it is an abstraction that serves to express the common concepts to all models of the same domain.

Nowadays, Meta-modeling is extensively used in the software engineering field and particularly in the models and methods engineering. Several meta-models have been proposed in related works, each of them is interested in specific areas.

In [5], Zachariadis et al, have proposed a meta-model for Engineering Adaptable Mobile Systems. It was a local component meta-model for mobile adaptive systems, implemented in the SATIN (System Adaptation Targeting Integrated Networks) middleware system. The SATIN was used to create and offer a number of applications that show different adaptation aspects. Also, C. Brunette et al in their work[7]. have defined a meta-model to design polychronous systems. As the name suggests, polychronous systems use multiple clocks, which means that signals do not need to be present in all instants. In this context, Brunette and Talpin have developed a meta-model and an open-source design environment for the synchronous language SIGNAL in the GME (Generic Modeling Environment) and Eclipse frameworks. They have also shown how this meta-model can be easily extended to provide designers with adequate concepts for the design of both control-oriented and avionics systems.

In testing field, Y. Hernandez et al. [1], have proposed a meta-model in order to validating web applications with regression testing. They have applied the power of model-driven software development in order to propose their own approach to generation of an automated testing script for validating the client-side of a web application that has migrated to new technologies. For this, they have provided a meta-model to support testing web applications based on the conceptual model. However, in this work, this approach remains specific to the regression tests of web applications in case of migration to new technologies; it does not offer a solution for all IT systems types. AR. Guduvan et al. [2] in their paper, have presented a test meta-model that allows for customization and maintenance of the testing solution, by providing a clear separation between the user data and test-solution provider data (with predefined extension points). It also keeps a separation between structural and behavioral elements. R. Wampfler. [3], in their work have proposed a meta-model that describes and represents the objects, methods and parameters used for the unit tests. This meta-model retains the link between test and implementation and most tests can be transformed according to this meta-model.

Until now, no meta-models are proposed for risk-based testing technique. We will define through this paper a new meta-model that represent risk-based testing concepts.

On the other side, various works in the literature have proposed in the risk-based testing scope. Some of them present new approaches. For example, Wendland, M et al. [16] have proposed a new risk based testing approach to generate risk-optimized test suites. This approach combines the model based testing principle and risk based testing by using test directives to systematic test case derivation and risk levels to risk-optimized test case generation. Moreover, Chen, Y and al. [17] have provided a method of test case selection based on risk element for regression testing. They have used risk analysis to guide test case selection, and measure the quality of the regression test suite.

3 Risk-based Testing

Risk-based-testing is a technique that use risk as bases to tests, it considers risks of the product as the guiding factor to support decisions in all phases of the test process. It is a method that assists in determining and prioritizing what to test, in order to optimize the effort of the testing and deliver product with good quality within the deadline.

In risk-based testing, the risk element is based on two to three factors: 1) Probability (P) that defines the likelihood of occurrence of a hazard or undesirable event. 2) Impact (I) that determining the consequence or the cost if the hazard or undesirable event is occurs in production. 3) Detectabiliy (D) that defines the ability to detect a hazard or undesirable event before it causes harm.

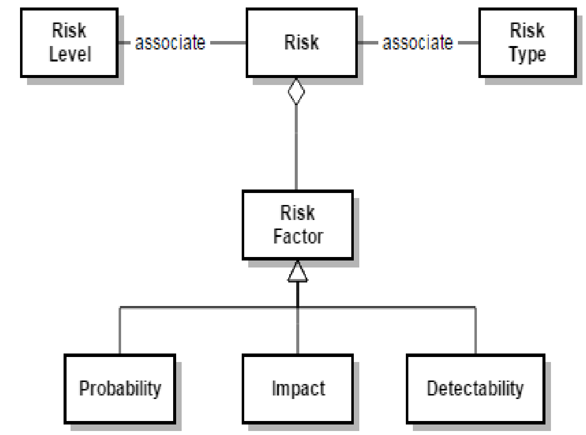

Fig. 1. Risk Elements in risk-based testing.

Typically, risk is defined as the combination of the Probability (P) and the Impact (I). However, several risk approaches and tools include Detectability (D) as an additional factor when calculating the risk level.

To express mathematically, the risk of an artifact x_i can be calculated as follows:

$$R(x_i) = P(x_i) * I(x_i)$$

Or

$$R(xi) = P(x_i) * I(x_i) * D(x_i)$$

The Risk-based Testing technique consists on producing prioritized tests cases with available resources and time by following a process composed of five phases (Fig.3) [8]:

1. Requirements management
2. Risks identification
3. Risk Analysis and Evaluation
4. Risk Mitigation or Reduction
5. Execution test cases according to prioritization and acceptance criteria.

Requirements management phase in which the customer needs, desires and constraints are collected, managed and classified as requirements. Requirements can be classified into functional requirements that define the capabilities that the product must perform to satisfy specific user needs, and non-functional requirements that define the qualities and the characteristics that the product must have.

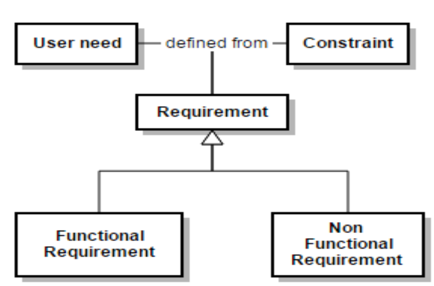

Fig. 2. Requirements types in risk-based testing.

Risk identification phase in which all potential risks and their characteristics are listed and documented in a risk register. The main purpose of risk identification is to ensure that all potential risks are identified in order to minimize the negative impact of an undesirable event.

Risk Analysis and Evaluation phase in which each identified risk is analyzed and evaluated by using the probability of occurrence, impact when occurrence and if the risk is easily detectable or not.

Risk Mitigation phase in which a plan to treat or modify the highest risks is setting up to achieve acceptable risk levels.

Execution phase that consists in executing test cases resulting from mitigation phase according to prioritization and acceptance criteria identified in the risks report.

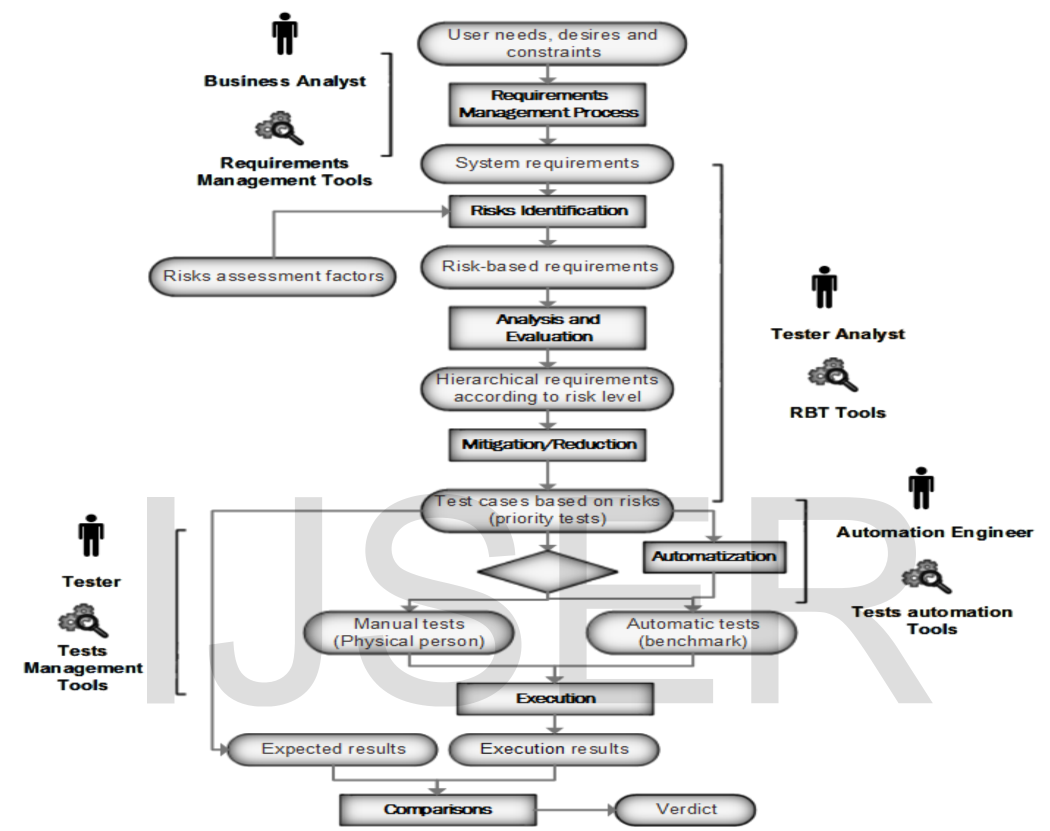

Fig. 3. Risk-based testing process [8]

In the risk-based testing process, a test case can take several states, passing from the user needs or constraints, requirement to the successful test case (Fig. 4). The requirements are functional that allowing to evaluate and validate all functionalities, features, programs and modules of the system and non functional to validate the characteristics of the system.

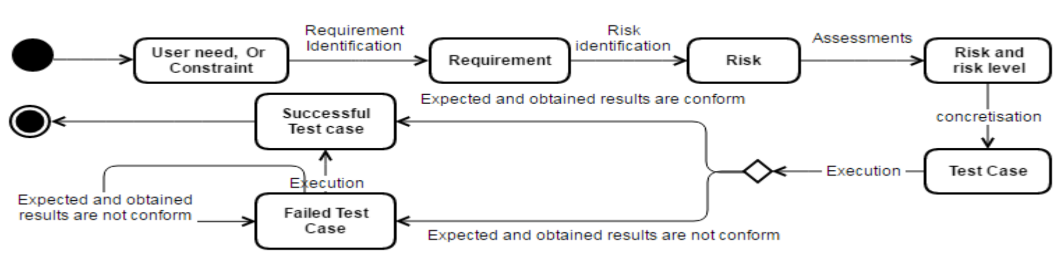

Fig. 4. A State chart diagram showing the different states of test Case in Risk-Based Testing Process.

4 Relationships between Risk Based Testing Elements in Project Management

Test activity is an integral part of the project, regardless of the models used for software development life cycle(SDLC) viz; agile model, spiral model, Iterative model or sequential model. Testing activities are closely linked to the others activities of software development, figure 5 (Fig.5) give the relationships between risk based testing elements in project management process.

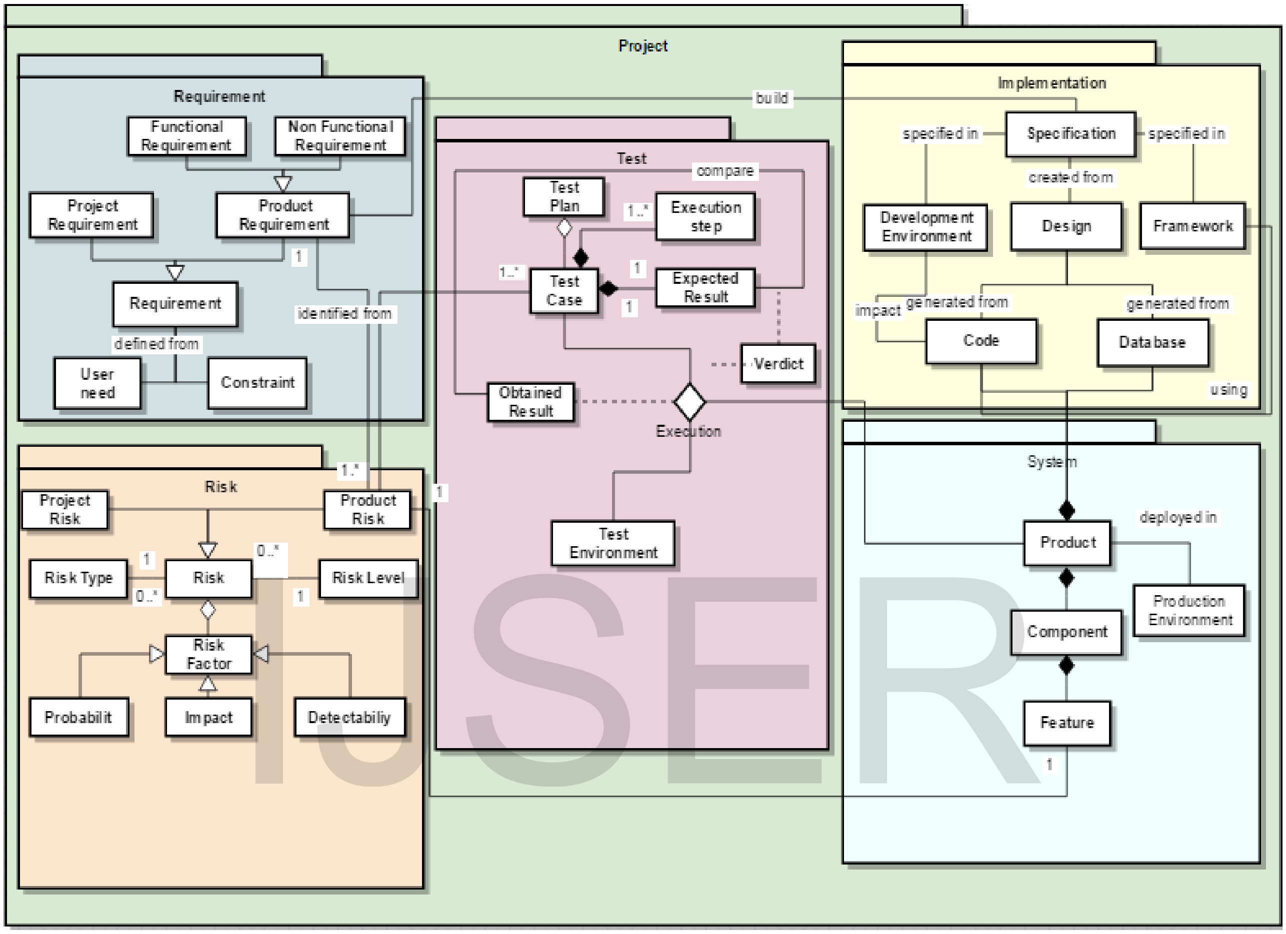

Fig. 5. A State chart diagram showing the different states of test Case in Risk-Based Testing Process.

5 The Proposed Meta-Model

A model is an abstraction of a system and a meta-model is an abstract description of a model. Meta-model is a formal definition of a model, it define the constructs and rules needed to create semantic models. A Meta-model facilitates the reasoning on model structure, model semantics and model use. According to Meta-Object Facility standard (MOF), a meta-model defines the structure to have by any model of this meta-model. In other words, any model must respect the structure defined by its meta-model [1]. The Meta-modeling is the activity that produces, among other things, meta-models that reflect the static structure of the models. It consists on specifying the concepts and the links between these concepts. Meta-modeling is widely used in information systems engineering and particularly in models and methods engineering. It's played a central role in all model-driven approaches like MDA, MDD, and MDSE [2].

We propose a generic meta-model with the purpose of representing and describing the general concept of risk based technique (Fig.6).

This Meta model is a class diagram, in which each fundamental concept is represented by a class and each existing relationship between concepts by an association. It contains a set of concepts needed to validate any risk based testing approach proposed in academia or industry.

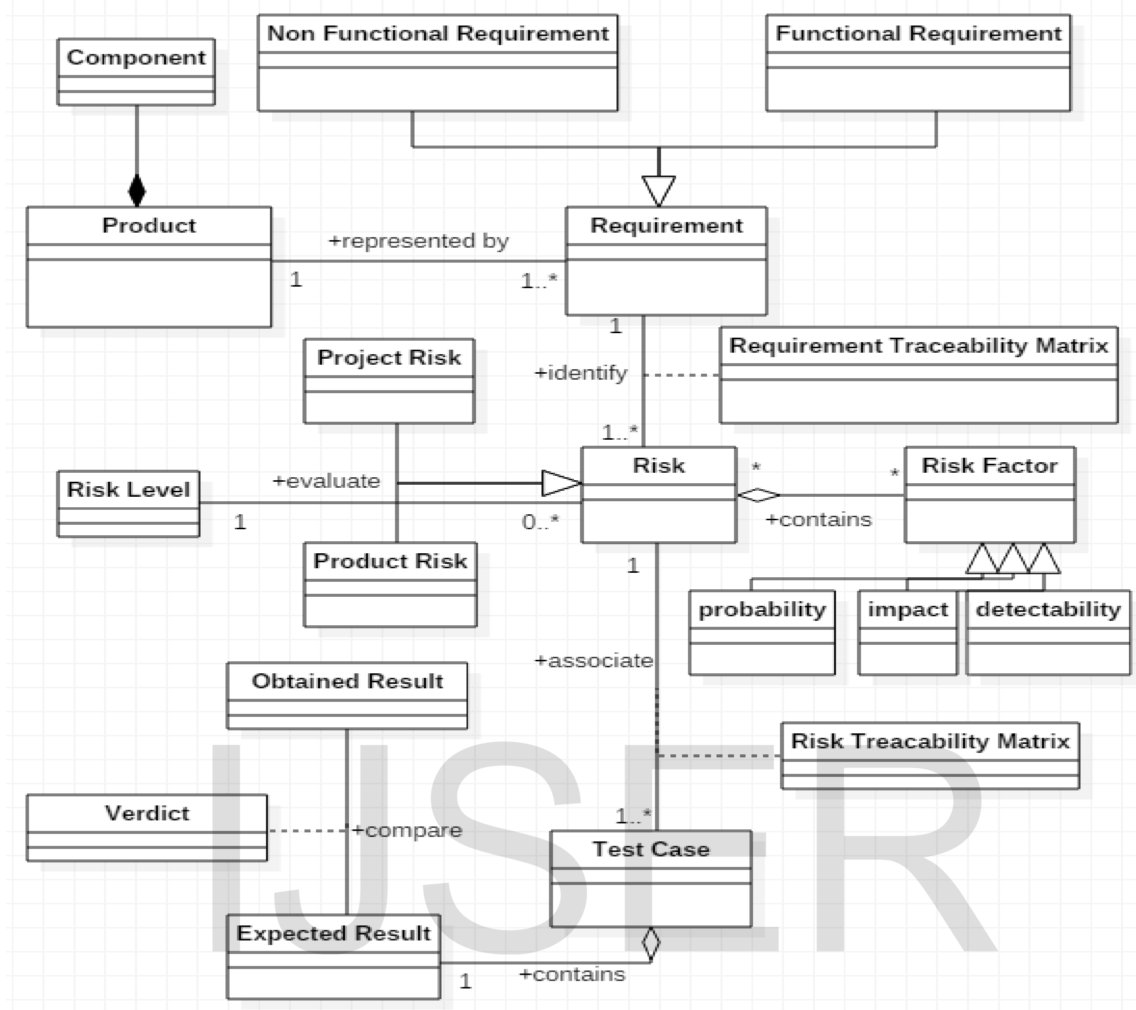

Fig. 6. Meta-model for Risk-based testing technique.

6 Discussion

From the fact that risk based testing has emerged as a major research area in academic and industrial, a large number of publications and new approaches are produced in this field. But there is currently a lack of a unifying conceptual framework or model that illustrates the common concepts of risk-based testing, and provides the essential characteristics of the various RBT approaches. Most of the previous studies or publications give new RBT approaches. For example Palanivel approach [11], which used risk analysis with threat modeling to test security of systems. On the other hand, some studies give the publications covering supporting techniques [13], integration of RBT into industrial practice [12], taxonomies [14]. For example M. Felderer et al[14]. have provided a taxonomy of risk based testing in which the principal aspects of RBT approaches are covered. This study helps to understanding the characteristics, similarities and differences of those approaches. It allows comparing risk-based testing approaches to support their selection and tailoring for specific purposes. Due to the lack of a unifying conceptual framework or model of risk based testing, the main purpose of this article is to provide a meta-model for risk based testing technique in order to present the common concepts of risk-based testing, and provides the essential characteristics of the various RBT approaches. This study gives a new support that can be beneficial and will help researchers who want to propose new RBT approaches.

Significance Statement

This study provides a unifying conceptual meta-model for risk based testing technique in order to present the common concepts of risk-based testing and provides the essential characteristics of the various RBT approaches. This study gives a new support to understand, categorize, and compare risk-based testing approaches to support their selection and adaptation for specific purposes staying within the RBT scope.

7 Conclusion

In this paper, we proposed a generic meta-model for Risk based technique. This meta-model will provide an active support in potentially useful knowledge during proposing any new approach based on the Risk-based-testing technique. In Software testing technologies such as risk-based testing approaches, each approach has specific concept and characteristics. The proposed meta-model represents the general concept and the characteristics of the risk-based testing technique, this meta-model can be beneficial and will help researchers who want to propose new Risk-based testing approaches. we have already worked on the proposal of a meta-model that represents the Model-based-testing technique in order to propose in the future a new approach that combines MBT (Model-Based-Testing) and RBT (Risk-Based-Testing) to overcome some model based testing limitations; and Make some case studies by applying the novel testing approach to obtain empirical results and compare our approach over existing approaches.

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