The Application of Object-Oriented Method in the Development of Large and Complex Test Projects

Research by

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Summary:

The paper highlights the challenges posed by the increasing complexity of electronic information equipment and the need for more advanced test design and management technologies. There needs to be more than the traditional single-mode test design and management technology to meet the requirements of large and complex test tasks.

This scientific article presents an innovative approach to tackle the challenges of large and complex test projects with an object-oriented analysis and design method. The authors thoroughly analyse the essence and connotation of the object-oriented way and introduce the basic process of test project development.

The article emphasises the crucial role of data and operation in object-oriented design. It discusses using three models - the object, dynamic, and function - in the problem space. The need for standardised development processes to control test risks is also highlighted.

A test project is a well-organized, well-managed, and coordinated project with three essential elements: method, available resources, and process. The key to designing and managing test items using engineering methods is to control the complexity and risk of the test. The central task of test engineering is to reduce the complexity of problems using techniques such as hierarchical decomposition. Risk control is a primary concern in engineering design, as product testing is a highly innovative and essential project with little room for future modifications.

The object-oriented method is well-suited for analysing and designing test projects to reduce risks and ensure successful completion. The object model classifies function departments according to their coordination relationships and responsibilities within the test project. The function model decomposes and assigns the project's overall work. From a risk control perspective, the function model's general work can be divided into three aspects: pre-research of key test technology, analysis of test demand and risk, and judgment of test results.

The object model of the test projects classifies the test implementation units' function departments according to their coordination relationship within the test organisation. The classification is based on their work contents and responsibilities in the test project. The most critical test work of the analysis and design of the test projects is to control and reduce risk, with the most significant risk being that of crucial technology.

This paper discusses how the object-oriented method can be applied to developing large and complex test projects. Using this approach, developers can create robust and maintainable test systems that are easy to understand, design, implement, and test.

Objectives and Methodology:

The goal is to present a development method for test projects based on the object-oriented approach, which offers a better solution for standardising the design and managing the risks associated with large and complex test tasks.

Features:

- *Object-Oriented Method*: The Object-Oriented Method uses objects to analyse and understand the problem space and then design and develop a solution space composed of objects. Since both the problem space and the solution space are made up of things, inconsistencies between the structures of the problem space and the solution space can be eliminated. Data represents

the static attributes of an object and its state information, while operations are used to change the dynamic behaviour of an object's state information. This approach helps to avoid data redundancy and repetition of operation instructions.

- *Object Oriented Methodology Model*: It establishes three models to study the problem space: the Object Model, which maps the relationship between objects in the problem space and describes the static structure of the system; the Dynamic Model, which describes how entities provide services and interact with the outside world; and the Function Model, which represents the services that the problem space can provide to the outer world.

- *Hierarchical decomposition* is a result-oriented tree structure composed of various parts of a test project, which determines the entire contents of the test project. It is used to control the complexity of the test.

- The *object-oriented decomposition* technique breaks down complex systems into smaller, more manageable components. It is based on object-oriented programming, which uses objects to represent and manipulate data. This approach can help control the complexity of test projects and make them easier to design, implement, and maintain.

The object-oriented decomposition in the test projects:

Research has shown that as the complexity of a project increases, the need to divide the original problem into different modules based on the object-oriented paradigm grows in significance. The object model of test projects classifies the function departments of test implementation units according to the coordination relationship of test organisations.

Three Different Models in the hierarchical decomposition:

The object-oriented methodology establishes organisations to study the problem space: the object, dynamic, and function models. These models are used to analyse, design, and implement software systems, including large and complex test projects.

- **Object Model**: The object model represents the static structure of the system. It describes the objects, classes, and relationships between them. The object model defines the data structures and organisation of the system. In the context of large and complex test projects, the object model can help determine the design of the test data and the relationships between different test components.

- **Dynamic Model**: The dynamic model represents the system's behaviour over time. It describes how objects interact with each other and how the state of the design changes in response to events. The dynamic model defines the control flow and logic of the system. In large and complex test projects, the dynamic model can help determine how tests are executed, and results are generated.

- **Function Model**: The function model represents the functional requirements of the system. It describes what the system is supposed to do and how it is supposed to do it. The function model is used to define the functionality of the system and its interfaces with other systems. In large and complex test projects, the function model can help determine what tests must be performed and how they should be performed. It can be divided into two types based on the top-level analysis: Overall Work Function and Support Functions.

Using object-oriented methodology, these three models provide a structured approach to analysing, designing, and implementing large and complex test projects. Developers can use these models to ensure their test projects are well-structured, efficient, and effective.

Basic process involved in the development of test projects:

The test work is divided into six stages, each with different priorities and objectives.

1. Mission requirement: Understand technical metrics and scope of the test, analyse and explain requirements.
2. Overall design: Prepare a general test plan and outline and explain functionalities to be tested.
3. Support needs: Various types of support are required, including command, communication, site, meteorological, logistic, and test equipment support.
4. Detailed design: Create specific plans for implementing test technology using a data-oriented or modular approach.
5. Test implementation: Draw up a test plan, organise test implementation, record test data and deal with test problems based on detailed design rules.
6. Analysis and summary: Systematically analyse collected data and compile test and technical summary reports to determine if technical metrics meet overall development requirements.

Test Item Function Model Analysis

The function model of the test project is mainly divided into three phases for controlling risk: the pre-research Phase, the analysis of the test demand phase, and the judgement of the test result.

Pre-Research Phase: In this Phase, technology designers must select the best possible key technology to be used over time. The test project's most crucial part is reducing risk and complexity. The selection and research of critical technologies often take longer to gather and may delay the project due to verification before implementation. It is heavily preferred to start working on this Phase well before the start of the project.

Analysis of Test Demand Phase: In this Phase, we should strengthen the study of scientific and technological information and track the flow of the project designed according to the pre-research Phase. This Phase is an integral part of technology development for the entire test project and may require repeated modification of technology developed to reduce risk factors.

Judgement of Test Result: This Phase involves compiling a test report and making modifications to develop the test project. From the above discussion and object-oriented metrics that decide usability, efficiency, complexity, and risk factors, it has been observed through much research that the OO paradigm has grown in strength in determining complex problems into minimal and understandable constructs.

Advantages of using Object Oriented Methods

The Object-Oriented Method (OOM) offers several advantages in developing large and complex test projects. Some of these advantages include:

- **Modularity**: OOM provides a clear modular structure for programs, making it well-suited for defining abstract data types in which implementation details are hidden. This can help increase code reuse and improve maintainability.

- **Re-usability:** Reusability contributes significantly to achieving high speed, low cost and low development cost. Using reliable and available similar modules as far as possible is better than designing new ones. OOAD is becoming popular due to its easy maintenance.

- **Test Complexity Optimization:** A large and complex test project has to solve problems. All these will lead to very complicated test work. Using Hierarchical decomposition, the text complexity can be reduced.

- **Effective Risk Management and Control:** Risks in test projects are of two types, risk in key technology used and risk in understanding the technical metrics; using Object Oriented Methods can help reduce risks due to technical metrics.

Overall, using OOM to develop large and complex test projects offers many benefits, including increased efficiency, modularity, organisation, and reliability.

Drawbacks of using Object Oriented Methods

Some of these challenges include:

- **Defects in Object-Oriented Models**: Defects in object-oriented models can result in poor-quality applications based on those models. It is essential to understand which defects commonly occur, why, and how they can be prevented.

- **Unfamiliarity**: OOAD is a new type of project management. Hence many development teams may not recognise its implications.

- **Challenges in reusability of design and software**: The compatibility of the software developed needs to be checked across all the environments, as selecting the wrong climate, language, or tools for a software development project can lead to countless unforeseen issues. The software should be developed keeping in mind its reusability. Otherwise, its cost will be higher, and its completion might not be achieved otherwise.

- **Importance of UML Models**: As project complexity increases, the importance of UML models in software engineering also increases. However, UML lacks formal semantics, has risks for inconsistency and completeness defects, and lacks modelling norms. These properties can result in poor model quality and defects.

Overall, while using OOM in developing large and complex test projects offers many benefits, it is essential to carefully consider its potential challenges and limitations when deciding whether to use this approach.

Proposed Solution

Complexity Control:

Complexity Control is a methodology used to control test complexity. It involves using a hierarchical decomposition structure, a result-oriented tree structure composed of various parts of the test project. This structure determines the entire contents of the test project.

The general steps for using this method are as follows:

1. **Identify the main components** of the pilot project, including the boundary, connotation, and objectives of the test project.

2. **Verify** whether each part is decomposed in sufficient detail for test design. If each component is decomposed in enough detail, continue to step four; otherwise, try to step three.

3. **Define** the test method and test conditions.

4. **Check** whether the decomposition is correct. This can be done by checking the following aspects:
    - The adequacy and necessity of low-level elements to be realised compared with the decomposed components.
    - The clearness and completeness of boundary determination for each element.
    - The rationality of the implementation plan for each constituent element.

Decomposition has several benefits, including making it easy to analyse and evaluate the decomposition process and ensuring scientific integrity. It also helps communication between test items.

Risk Control:

Risk Control is a process that involves managing and mitigating risks associated with understanding technical metrics in task demand. This can be achieved through several methods, including:

- We are communicating with the overall demonstration unit and the superior authorities during the preparation process to avoid risks.

- **Organising seminars,** if necessary, to discuss and find potential risks.

- **Solidifying** problems not identified during the seminar in the form of test methods at the test outline review conference. This helps to understand the technical metrics better.

- **Controlling** the application of new technology in the test process when key technologies cannot be resolved entirely or verified in the overall test design.

Future Work

Object-oriented programming languages provide many libraries of objects, and code developed during a project can be reused in future projects. The analysis and design paradigm is such that complexity as well as risk in the conduction of test is reduced to a great extent and the future reliability and enhancements can be done easily.

However, much work must be done to improve complex project efficiency, reliability, and reusability. Risk control methods must be enhanced, and complexity control methods must be researched and updated. A ruleset, metrics, and visualisation techniques should be developed to improve the quality of UML models during development. Like coding conventions, a modelling convention should be set up to prevent defects and ensure uniformity of modelling within an organisation.

Therefore, work needs to be done on the abovementioned points and concerns.

Conclusion

This paper proposes an object-oriented analysis and design method for large and complex test projects. It describes the key points of each stage of the test project and how test complexity and risk can be reduced to a much greater extent so that it is easy for the software developers to handle the complexity. The paper proposed a development method of the object-oriented test, which standardized the development process, and solved the problem of test risk control in the

design and development of the project. It studies the application of the object-oriented analysis and design method in the test project.

Contributions

- Krishna Aggarwal: Summary
- Vineet Kumar: Objectives and Methodology.
- Anvit Gupta: Test Item Function Model Analysis, Future Work, Conclusions.
- Sarvasva Gupta: Advantages and Drawbacks of Using Object-Oriented Methods
- Utkarsh Lohiya: Proposed Solution.

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- Object-Oriented Analysis and Design by Grady Booch.
- The given article.