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AN OPTIMUM TEST MANAGEMENT SYSTEM
– A case study

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- A case study

Testing is the process of finding out how well the product works and test management system refers to a system that manages the entire testing life cycle of a product. This thesis aimed to improve the testing system of the commissioning company by building an ideal test management system.

In the theoretical part, the general concept of testing and test management system is explained. The introduction of testing, testing life cycle, test management system and test management tool are discussed. Guidelines for selecting a testing tool are also provided.

In the practical part, the requirements for the new system were identified through interviews, discussions and a survey. A pre-selection of six testing tools was carried out for detailed evaluation in a pilot environment. At the end of the examination, TestLink was chosen as an ideal test management tool for the commissioning company. After the selection of the tool, the real testing environment was set up, and the new system was compared with the old system.

As a result, the new system seemed promising, and the company decided to implement the system. However, in the future, further research needs to be conducted, and improvement should be made in test plans and test cases according to the company’s current status. The objective of implementing a test management system in the company was met.

KEYWORDS:
Testing, Test Management System, Testing Tool, TestLink
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<th>Description</th>
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<tr>
<td>ANSI/IEEE</td>
<td>American National Standards Institute/Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>APTT</td>
<td>AINA Push-To-Talk</td>
</tr>
<tr>
<td>ASB</td>
<td>AINA Smart Button</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility</td>
</tr>
<tr>
<td>HW</td>
<td>Hardware</td>
</tr>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
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<tr>
<td>ID</td>
<td>Identity document</td>
</tr>
<tr>
<td>IE</td>
<td>Internet Explorer</td>
</tr>
<tr>
<td>IOS</td>
<td>iPhone Operating System</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol</td>
</tr>
<tr>
<td>ISO/IEC</td>
<td>International Organization for Standardization/International Electrotechnical Commission</td>
</tr>
<tr>
<td>OS</td>
<td>Operating System</td>
</tr>
<tr>
<td>PHP</td>
<td>Hypertext Preprocessor (Personal Home Page)</td>
</tr>
<tr>
<td>PTT</td>
<td>Push-To-Talk</td>
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<tr>
<td>QA</td>
<td>Quality Analyst</td>
</tr>
<tr>
<td>RTM</td>
<td>Required Test Matrix</td>
</tr>
<tr>
<td>S/N</td>
<td>Serial Number</td>
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<tr>
<td>SDLC</td>
<td>Software Development Life cycle</td>
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<tr>
<td>STLC</td>
<td>Software Testing Life Cycle</td>
</tr>
<tr>
<td>SUT</td>
<td>System Under Test</td>
</tr>
<tr>
<td>SW</td>
<td>Software</td>
</tr>
<tr>
<td>TMS</td>
<td>Test Management System</td>
</tr>
<tr>
<td>TMT</td>
<td>Test Management Tool</td>
</tr>
<tr>
<td>XML-RPC</td>
<td>Extensible Markup Language-Remote Procedure Call</td>
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1 INTRODUCTION

There is continuously a part of changes going on in everyday life. The world is progressing rapidly, and the vast majority of the headway is the result of forward-moving innovations. People are increasingly subordinate on different innovations for a way of life. Due to a widening demand for advancements, people are also expecting products and services of incredibly extraordinary quality. With the wide application of technology, it is outstandingly essential for people to have positive developments with higher qualities. In this way, companies are under enormous pressure to create products and services of high quality and in great amounts. (Mili & Tchier, 2015)

Organisations have turned out to be mindful of the primary job of testing in the innovation advancement life cycle to deliver brilliant products and services. Testing is the way toward assessing any products and services to recognise the contrasts between the given input, the actual output, and the expected output alongside its prerequisites and risks. Other than being the last stage of the product development life cycle, testing is viewed as the first critical stage with fundamental objectives: validation and verification. It gives the right response to whether the organisation is building the correct products and services that meets its specification. Testing is rehashed habitually to guarantee the quality after each alteration of the product. Therefore, performing testing is extremely important before releasing the final product. (Watkins, 2004)

Other than the imperative significance of testing, it is impossible to have any testing system consummately liberate from bugs. The principal components causing this are the presence of intricacy of the computer system, the fallibility of the advancement process and the association of the human in the testing procedure. Most importantly, the testing process, which is efficient and productive that can discover and adjust as many defects as available, should be considered as the ultimate system. In integration, this system must be able to give a qualification of confidence that a delivered product is acceptable for its intended purpose before its release. Similarly, a detailed analysis must be conducted before implementing a tool for the system. The time and energy spent on logically choosing a test automation tool and the system must guarantee fruitful test execution. Hence, the identification of the right automation tool for an ultimate system is fundamental to ascertain the achievement of the testing project. (Watkins, 2004) (Limaye, 2009)
The main objective of this applied thesis was to figure out an optimum test management system for the commissioning company to improve and accelerate its current testing process. The company did not have any testing management system, and the existing testing system was unsatisfactory. Similarly, the company wanted to introduce a test management system to improve the present testing process, control overall testing, make it more flexible and reduce extra time consumed during testing management. Therefore, the thesis was conducted to investigate the current testing system of the company, generate ideas on how it can be improved, and build an ideal test management system.

The thesis has different phases like theoretical understanding of the topic, researching, selecting an ideal testing tool and explaining why, performing testing with the chosen device, comparing and evaluating the new and old testing system and lastly the conclusion. Chapter 1 introduces the background of testing, objectives of the thesis and the chapters of the thesis. Similarly, Chapter 2 provides an overview of testing, test management system and testing tools. Chapter 3 elaborates the research processes, including interviews and a survey. Chapter 4 deals with the current testing system of the company, describes selected testing tools with an explanation of why the specific testing tool was selected and how the system was set up for the company in a suitable format and compares both systems. Chapter 5 concludes the thesis. Altogether, the thesis highlights how an optimum test management system can be built.

1.1 AINA Wireless Finland Ltd – the case company

AINA Wireless Finland Ltd is an ICT service organisation which creates solid-featured wireless communication gadgets for push-to-talk over IP. With the cumulation of engineers and international business professionals who have developed and marked Smartphones, Bluetooth accessories and Remote-Speaker-Microphones for fire, emergency, safety, industry experts, and military for more than 20 years, the organisation has developed a next-generation Bluetooth speaker-microphone that is compatible with both iOS and Android.
smartphones and various PTT applications. Examples of PTT applications are Zello, ESChat, Mobile Tornado, AINA PTT, AT&T Enhanced PTT, StreamWide, Verizon PTT Plus, Kodiak PTT, Azetti, Talk-IP, Telo PTT and Group Talk. (Wireless, 2019)

The company guarantees high-quality gadgets to its clients as it has given close consideration to each detail inside the mechanical structure, hardware and software advancement, and manufacturing steps. With the slogan “Stay connected while keeping your phone in a safe place”, AINA products combine developed client propensities and practicality with the versatility of modern communication and information technology. (Wireless, 2019)

The products of company control functions such as push-to-talk, telephone calls, crisis alarms and channel switching with the goal that the clients never need to remove their phone from their pocket. (Wireless, 2019)
2 TESTING AND TEST MANAGEMENT

2.1 Testing

According to ANSI/IEEE 1059 standard, testing is defined as "a process of analysing a software item to detect the differences between existing and required condition and to evaluate the features of the software item." Likewise, testing is a process which targets to distinguish failures in the system and assess its level of quality to acquire client fulfilment (Homes, 2012). It is a vital part of the software development life cycle (SDLC) from the initial plan throughout development until the merchandise is taken out for marketing (Hass, 2008). Mostly software testers, software developers, project leaders, and end users are involved in the testing process. Testing focuses on finding the defects, within the most limited possible timescale, in order to convey high-quality product (Homes, 2012). Rigorous testing of software, including their documentation, permits a decrease in the likelihood of disappointment throughout the execution of the product and adds to moving forward the quality of that product. Thus, testing plays a significant and primary role in SDLC.

2.1.1 ISO/IEC 25010 Standards and Testing Types

The primary objective of the ISO/IEC 25010 standard, one of the most popular quality standard, is to address few familiar human inclinations that can unfavourably influence the distribution and approach of a software development project (Software and Systems Engineering, 2017). It proposed a quality model for a product with eight significant characteristics such as functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability and portability, each containing the sub-characteristics as shown in Figure 2. These characteristics are categorised into two main sections; functional and non-functional. The evaluation of these functional and non-functional characteristics are imperative, which is possible through testing. (Homes, 2012)
Functionality testing concentrates on the functions of the software system, what they are doing, the service provided, and also the needs covered by them (Homes, 2012). It is mainly performed on a complete system to figure out the system's functions according to its specific requirements. It embodies perspectives like quality, accuracy, ability, security and purposeful compliance. Testing types such as unit testing, integration testing, system testing, sanitary testing, smoke testing, interface testing, regression testing, and acceptance testing fall under this category of testing.

Non-Functionality testing mainly focuses on the way the services are provided (Homes, 2012). Except for functional characteristics, they contain all other features with respective sub-characteristics. Examples of these features are reliability, performance efficiency, usability, security, compatibility, maintainability, and portability. Testings types such as performance testing, stress testing, load testing, volume testing, compatibility testing, security testing, install testing, recovery testing, usability testing, reliability testing, compliance testing, and localisation testing fall under this category of testing.
Moreover, both of the tests can be executed at all test levels. The non-functional defects usually take a long time to correct; thus, it is smart to practice non-functional tests before or at the same time with functional tests (Homes, 2012).

2.1.2 Testing Levels

All the phases of SDLC go through the testing. There are different levels of testing which help check the behaviour and performance of the software. These testings are designed to recognise missing areas and reconciliation between the SDLC states. Testing levels are mainly categorised into four levels, such as unit testing, integration testing, system testing, and acceptance testing. Each of these testing levels has a specific purpose and involves numerous testing types.

![Levels of Testing](image)

Figure 3. Testing Levels.

Unit testing is a software improvement procedure which includes a synchronised application of a wide range of deformity avoidance, and detection methodologies in order to decrease software advancement dangers, costs and time (Binder, 1999). This type of testing is conducted in every module separately to verify that each component meets requirements and specifications before promoting to next level of testing. Typically, it is carried out with access to the source code, often with the developer's assistance or by the developers. (Homes, 2012) (Watkins, 2004)
The aim of integration testing is to focus on the interfaces between software components and between the several parts of the computer program and the systems (Homes, 2012). Numerous previously tested software components are combined and tested, forming a group to ensure that the unified system functions as required and is qualified for system testing (Beizer, 1990). Generally, it is performed by developers or technical architects.

System testing is performed on a complete unified system which checks the overall interaction of components as per the requirements (IEEE, 1990). It is conducted at the system level focusing on how the whole system works (Homes, 2012). Functionality testing, performance testing, and reliability and security testing are involved in this testing type. It is ordinarily executed by test groups, in some cases, with a high degree of independence (Homes, 2012).

Acceptance testing focuses on reaching a level of certainty within the system, for functional or non-functional aspects. It is conducted to discover whether the requirements of the system and expectations of end users are met. Alpha testing where development group perform testing and beta testing where end users do testing fall under this testing type. In this test, if there seem to be too many failures or the confidence in the system is not reached, or customers are more doubtful about future deliveries of the system, then it is not considered favourable for that system. (Homes, 2012)

2.2 Software Testing Life Cycle (STLC)

Testing does not only mean to execute software and find failures and defects. It is also essential to plan, characterise objectives, recognise test conditions, make test data, make the beginning and ending criteria, test situations and lastly control all these activities (Homes, 2012). Software testing life cycle represents these activities at various phases of the testing process of software. There is no fixed standard STLC, but in general, it comprises of mainly five phases which are discussed below. Every phase has its entry criteria and delivery. The order of these phases is just a guideline, and it is not necessary to follow these steps in strict order (Hass, 2008). These phases are repeated at each test level and for each test campaign. For example, test planning and control are carried out throughout the testing process according to the situation and need. Likewise, in some cases, test analysis and design are performed alongside with test execution. As the generic test process is iterative, these phases are performed more than once in an...
iterative way until the exit criteria are met. These processes can only be fruitful if they are managed and organised properly. (Mili & Tchier, 2015)

Figure 4: Software Testing Life cycle (STLC)

**Test planning and control**

The main purpose of test planning is to organise tasks and coordinate with all stakeholders (Homes, 2012). In this step, the testing goal is verified, test objectives are defined, and important choices are made to convert the test strategy into an operational plan for the execution of the real test (Hass, 2008). The test plan should be practical, contain boundaries of testing, and include dangers and assumptions made during testing (Limaye, 2009). The main purpose of test control is to guarantee that the arranged exercises are on track by checking what is going on and taking remedial activities as appropriate (Hass, 2008). During this step, the progress of activities is measured in terms of used resources and objective reached by that activity.

**Test analysis and design**

The chief objective of the test analysis and design phase is to build test designs containing test conditions, test cases and an essential test environment based on a
review of test objectives and approach laid out within the test plan (Hass, 2008) (Limaye, 2009). The study of the test premise permits the definition test objectives, their prioritisation, and the assessment of the testability of the test premise and test goals. Comparatively, the test design comprises of applying the test goals beneath accessible test conditions, and after that, applying the test conditions to test cases and also including both test data and expected outcomes. (Homes, 2012)

**Test implementation and execution**

The purpose of this phase is to organise the test cases in methods and to perform the physical test within the appropriate environment (Hass, 2008). Test execution of the tests is what everyone has been holding up for the minute of truth. Test execution within the test environment empowers the recognisable proof of contrasts between the anticipated and the real outcomes and incorporates assignment connected to the implementation of test cases, test strategies, or test suites. At the same time, test execution cannot verify that every bug has been recognised. (Homes, 2012)

**Analysis of exit criteria and reporting**

Analysis of exit criteria ambition is evaluating the test object in relation to the test objectives and standards defined in the test plan. Test execution, control, recording, retesting and regression testing should proceed until the test criteria are accomplished (Hass, 2008). The detailed examination can distinguish regions where there is no legitimisation to embrace advance tests to reach the expected exit criteria. The outcomes of testing activities interest everyone in the project. Thus, the report should contain every detail and be understandable.

**Test closure activities**

The goal of the test closure activities is to solidify experience and test environment inappropriate control for future utilise. They can also be useful for comparison in the future. (Hass, 2008)
2.3 Test Management System (TMS)

The activity of handling the whole software testing process is called test management. According to the IEEE standard 829-2008, the test management process is a set of tasks concerning the test planning, controlling, analysis, designing, implementing, executing, reporting and completing the test activity. It is the method of organising and controlling test forms, test resources and artifacts for testing projects.

In every testing process, it is essential to have a robust testing team with proper management and collaboration. The main goal of a productive test team is to manage all the testing task successfully and efficiently to guarantee that the company produce the required product to a decent level of quality within the estimated period, resources, and costs (Watkins, 2004). There are different roles involved in the testing process; for example, test manager, test leader, test analyst, and tester. The test manager behaves as the link between the test team, the development team, and the management team, so the test manager should always know the value of testing and be able to explain it to the management and the business team in a transparent way (Hass, 2008). Moreover, the test manager is responsible for reckoning test assignment and organising and arranging the test activities over time (Homes, 2012). It is crucial that the test manager understands how testing contributes to business goals. Correspondingly, the test team leader runs the testing project by firstly giving the task to the testers and the analysts, secondly looking after the progress of test to ensure its completion within the given time, and, finally, making sure that the test reports contain every detail necessary for further use (Watkins, 2004). Similarly, the test analyst is in charge of the design and implementation of test scripts. The tester is mainly accountable for the execution of the test scripts and the explanation and documentation of the outcomes of the test cases for further discussion and review.

The main objective of test management is to progress test achievement and subsequently enhance the software quality. Management incorporates planning, organising, directing, coordinating and controlling the alter in the system (Limaye, 2009). Thus with the assistance of well-planned and well-managed testing management process, it is possible to create an excellent product with the utilisation of available resources.
Importance of TMS

It is next to impossible to undertake in-depth testing to test the whole components in the system, so choosing an appropriate test to design and execute is vital. During testing, many artifacts such as plans, requirements, specifications, design, test cases, and codes are formed, used, and changed (Limaye, 2009). These artifacts undergo several changes as the software is developing and improving over time, which leads the testing process to become more delicate and intricate. One needs to manage those variations skillfully so that the product is not affected in any harmful way (Limaye, 2009) (Majchrzak, 2012). As the testing process is complex and different people with various roles are involved, the demand for the test management system in a company is extremely high.

A test management system permits a balanced and efficient utilisation of available resources, proper coordination of test activities with design and promoting activities for software. In other words, it supports every event in the software testing life cycle with the overall development of the software. Similarly, it increases the effectiveness of testing activities. It also guarantees that every data of the testing process are accessible and comprehensive to all shareholders (Hass, 2008). Additionally, it gives high adaptability of test structure abilities and controlling power over test execution. Moreover, it is an extensible system which provides a sturdy test structure and test execution abilities and a framework for participating with multiple testing tools that create test cases and help analyse the state of the software. With precise attention, an effective test management system increases end-user satisfaction and leads to fruitful projects.

A test management system seems to contribute to an improved overall testing development process with minimal cost and maximum use of available resources resulting in improving software quality (Majchrzak, 2012). It also makes the testing process extra systematic, governable, and capable of advancing in coordination with testing tools. Similarly, TMT and forward TMS are part of advanced test mature model levels (Majchrzak, 2012). To summarise, an efficient and scalable test management system with a suitable test management tool is a must-have for a company.
2.4 Test Management Tool (TMT)

According to Craig and Jaskiel (Craig & Jaskiel, 2002), "testing tool is a software application that helps automate some part of the testing process that would otherwise be performed manually." The testing tool can either be a software or hardware product. It typically includes specification management modules that enables automatic generation of the Requirement Test Matrix, which is one of the metric to point functional coverage of a System Under Test (Wikipedia, 2019). Besides, it also determines how testing is planned, reports the status of QA activities, and systematically organise test assets.

The use of automated tool increases test reliability, enables execution of task which is not possible to carry out by a human, and improves the efficiency of repetitive tasks, such as regression tests. TMT provides support for project management, test traceability, incident and defect management support, version and configuration management of components to be tested, test schedule, risk analysis, and reporting tools. It saves testers time during testing and simplifies the testing process. Similarly, it can also support the handling of test documentation such as plans, test specifications and test procedures, and even traces between test cases and requirements. Thus, the overall advantage of TMT is that it can assist in the management of all activities in testing. (Homes, 2012)

On balance, having a test management tool is regarded as a positive addition to the testing process, but it needs careful considerations and planning before implementation. It is essential to withhold the hypotheses, assumptions, and limitations associated with the use of tools (Majchrzak, 2012). Acquiring a tool does not guarantee the success of any testing activities. In reality, the use of human intelligence, various test techniques, and the acquired experience is essential to organise, plan and implement test activities. Generally speaking, the tool can help the execution of a certain number of events, but their use also adds a certain amount of risks to the project. (Homes, 2012)

Testing is a complicated, costly and time-consuming process, and the testing tool plays a vital role in the testing process. Along with assisting in testing management, the testing tool can also cause few problems in the testing process. Hence, it should be noted that both advantages and disadvantages exist in the testing tool.
2.4.1 Choosing a Test Management Tool

Introducing a tool in the testing system is usually done to improve test efficiency in defect detection or to reduce the duration of the test campaign or the testing costs (Homes, 2012) and to support the existing maturity in testing (Hass, 2008). The selection of the tool cannot be made without detailed study. Few guidelines on how to select an ideal tool for the company are described below.

Firstly to introduce any testing tool in any company, it is vital to understand the baseline of the testing process of that company through its current practices for software testing. Similarly, it is also necessary to identify every other existing process which affects the company's testing process. Likewise, profitable and efficient project objectives for using the tool should be identified, which is the foundation of a test management system. Furthermore, short, mid, and long term views must be considered to evaluate the profitability of the considered choices and then, elevate the benefits for the organisation. Tools are usually expensive to buy or expensive to implement and maintain in the organisation so; the long-term testing tool strategy must be considered. Secondly, pre-selection of the list of tools should be done from research on the internet, which almost meets previously defined objectives. After this, the selection of only a few tools which best answers the identified selection criteria should be done. Further testing of the tools in a pilot environment should be done to measure and compare benefits and also to identify improvements. In addition, detailed evaluation and performance of trials should be done. The open-source and free tool should be considered first because commercial tools are often costly. The tool should also be easy to use for testers. Finally, the selection of an optimum testing tool must be made which can cope up with the company's current situation as well as with the development in the company for at least the foreseeable future. (Hass, 2008) (Homes, 2012) (Watkins, 2004)

The careful consideration and planning should be done before implementation of the tool such that the tool does not end up as "shelfware". The selected tool should always meet the desired criteria. After the selection of the tool, a proper configuration should be done such that maximum utilisation is made. The functionality of the tool varies with many aspects such as test team and its configuration. Similarly, every tool has its drawback. As a summary, it should be noted that the tool itself is not a miracle solution, and its result mostly depend upon its utilization.
3 RESEARCH

Research is considered to be the underlying and compelling asset in driving today’s world into headway. It is an application of the scientific approach in working out the issues. It is a systematic, formal and comprehensive process of carrying on the scientific method of analysis. According to Clifford Woddy, (Kothari, 2004) (Pandey & Pandey, 2015) “research comprises defining and redefining problems, formulating a hypothesis or suggested solutions, collecting, organizing and evaluating data; making deductions and reaching conclusions; and at last, carefully testing the outcomes to determine whether they fit the formulating hypothesis.” Redman and Mory define research as (Redman & Mory, 1933) “a systematised effort to gain new knowledge.” Research, an application of the scientific method in solving the problems, is a systematic, formal and concentrated procedure of carrying on the logical technique for examination (Pandey & Pandey, 2015). The research methodology includes research methods, the logic behind the methods used in the context of research study and explanation to use of a particular purpose.

The figure beneath speaks to the general research process with various steps firmly identified with one another. Its levels and connection between one another appeared with an arrow provide a useful procedural rule. However, it is not mandatory to follow each progression in any particular pattern and neither these steps are not unrelated and nor they are independent and unmistakable.

Figure 5. Research process.
First, figuring a research objective is the most critical advance in the research process. Research objective should be looked after cautiously and fundamentally because it recognises the primary goal. Evaluation of research objects in the light of financial condition, time available, one's ability and information available is essential. In the same way, the main objective of this thesis is to find the solution for an optimum test management system for the case company. (Kumar, 2011)

Second, the use of suitable methods for finding answers to research questions is vital in the research process. For any examination, the choice of a fitting inquire about the plan is significant in empowering anyone to reach substantial discoveries, comparisons, and conclusions. It is critical to guarantee that the selected research design is significant, workable and reasonable. The most popular qualitative research techniques utilised nowadays are action research, case study research, ethnography, and grounded theory (Myers, 2013). Action research replaces instinctive choices by more consistent and experimental findings. For this reason, action research was considered as an appropriate inquire about strategy for the thesis. (Kumar, 2011)

Third, deciding on the sampling technique, the appropriate sample size and about constructing a research instrument for data collection is considered as the first practical step. Pre-testing a research tool is an integral part of instrumental construction. Likewise, in this thesis, interviews, questionnaires, and survey were executed along with the experimental set-up of the selected tool with an appropriate sample. (Kumar, 2011)

Finally, the analysis of data using distinctive explanatory procedures and validating the results using various validation standards was made to set up the authenticity of the results. After a review of data, discoveries were examined, and conclusions were drawn to make the study useful and relevant for future utilisation. (Rana & Sharma, 2016)

3.1 Action Research

According to Kurt Lewis, action research is a method of searching, planning and developing an action plan to obtain results. It is an interactive process that is mainly concerned about taking care of issues and discovering appropriate arrangements and settling on a legitimate choice (Myers, 2013). It is the most suitable and used type of research in applied science which requires embedding prescribed changes to a procedure, bearing in mind to take care of an issue and to complete research to decide
the impact liveness of recognised changes (Igwenagu, 2016). It aims at tackling a known problem dependent on suggestions made to a process (Igwenagu, 2016). The characteristics of action research are innovative, continual, pro-active, strategically driven, participatory, interventionist, problematized, deliberate, documented, understood, generation of knowledge about practice, application of knowledge to practice and disseminated (Tripp, 2005). It is an iterative cycle of four steps: plan, act, observe and reflect. Problem-solving, for instance, starts with recognising the issue, arranging an answer, executing it and lastly observing and assessing its viability. The following figure exposes the four steps of action research.

![Action Research Spiral Model](image.png)

Figure 6. Action Research Spiral Model.

In this study, the researcher attempts to develop results and obtain solutions of practical value to the company and at the same time, develop theoretical knowledge. The action research cycle in this research started with identifying the requirement for an optimum test management system for the company. Based on data collected from interviews, surveys and discussions; the action plan was done, and further research for choosing the right tool was taken into action. As soon as a testing tool was selected, the work was implemented by testing the chosen tool for further observation. Every time a new tool was executed for sample testing, the inspection was made based on company requirements. This process was continued until the right tool was found which fulfilled all the needs of the company for future implementation. After the selection of the appropriate tool, the set up of the testing environment was done for using it for real work. Furthermore, the author of this study reflected how the whole process of action research was done and gave suggestions on how to continue after the end of this study.
3.2 Data Collection

The capacity of data is vital to the fruitful outcome of any research project (Collis & Hussey, 2009). The strategy for information accumulation should empower specialist to gather all the data expected to respond to the exploration questions (Myers, 2013). Myers (Myers, 2013) referred that the most normally utilised in subjective research are meetings, hands-on work, and using archives. The collection of data started with informal interviews followed by a further study on topic related matters and survey side by side in this research. Some data were gathered with the help of company workers using methods like informal meetings and discussions. While other data were collected through an in-depth study of different testing tools and related topic on different websites.

3.2.1 Interviews

Various interviews and meetings were made with the different level of workers of the company. Interviews are a technique for gathering information in which close members are posed inquires to discover what they do, think and feel (Collis & Hussey, 2009). Furthermore, an unstructured meeting is one where the inquiries have not been arranged already but rather develop amid the interviewee’s answers in more profundity (Collis & Hussey, 2009). Interview with few questions was conducted with quality analysers regarding features and expectations on the new system. In addition, discussions with different workers, especially the thesis commissioner, were done during the whole process. On the one hand, the CEO of the company wanted the system to be easy to learn and use, automated, efficient, and economic. On the other hand, it was noted that the QAs wanted the following features in the new system:

- Simple interface to check test results and compare them.
- Easy to add, manage, update and delete test cases functionality.
- Web-based application.
- Easy to learn and use.
- Search function with keywords or version number or else.
- Feature with regression test for failed or blocked test cases.
- A system that contains test cases with id for JIRA item.
- A system which supports test plan integration for individual tests.
➢ Should contain varieties of test results like a bug report, failed test cases report, passed test cases report, overall report, and other possible reports.
➢ Reports with all the detailed information like phone, phones operating system version, application, device s/n, and their versions.
➢ Should contain all current labels in the acceptable form.

3.2.2 Survey and Analysis

Survey research is defined as “the gathering of information from an example of a person through their responses to questions” (Check & Schutt, 2012). A survey consisting of thirteen questions was designed in the English language on 4 March 2019 with the help of ‘SurveyLegend’ website for the workers of the company. It was made to gather workers opinions on the current testing system, challenges, the requirements for a change in the system and any suggestions on a new system. Questions were made and updated remotely time to time according to the situation before uploading/adding it into the website. Survey link was sent to all the workers through company mail on 4 March 2019. The deadline was announced to be on 15 March 2019 with a further motivational request to take part in the survey through email on 11 March 2019. A total of 16 employees responded to the survey. Some of the respondents did not answer all the questions which affected the quality of the research.

The screenshot of the whole survey with brief analysis are shown below:

![Welcome to the Thesis Survey](image)

Figure 7. Starting page of Survey.
1. What is your role in AINA Wireless Finland Oy?

![Roles of Respondents]

Figure 8. Roles of Respondents.

The first question of the survey asked the respondent about their role in the company. The purpose of this question was to find out the professional diversity of the company. Three respondents were software developer/designer, and other three were chief engineer hardware while rest of them were either CEO or director of SW development or ecosystem tester or HW design engineer or marketing assistant or software tester or vice president of global sales and marketing, mechanical design engineer, quality assurance specialist or technical manager.

2. How long have you been working with AINA Wireless Finland Ltd? (in years)

![Working time of respondents with the case company]

Figure 9. Working time of respondents with the case company.
The above chart shows respondents total time spent working for the company. It is visible that the majority of the respondent has been working for the company for more than two years. A similar amount of respondents were found working in the company for less than a year. Intensely few respondents worked in between one and two years.

3. What are/have been the biggest challenge/s working with the company?

![Figure 10. Challenges faced by respondents in the company.](image)

The primary purpose of this open-ended question was to find out problems faced by the employees in the company. Only 12 respondents answered this question with the majority of answers reflecting limited resources that lead to a heavy workload. Other respondents wrote that the various challenges faced by them are getting the requirements, software bug hunting and working with partners to provide robust solutions for the customers.

4. What type of testing are you involved in the company?
The fourth question was specially designed to know the types of testing performed during product development inside the company. Versatile answers were received because different testing is essential in every stage of product development. The above survey answers illustrate that examinations for the mechanical drop, chemical, dumper, waterproof, electronic, EMC, production line, application, device, HW, software, qualification, functional and module were involved in the company.

5. Rate the current testing system of the company.

![Rating of the current system](image)

Figure 12. Rating of the current system.

This question asked the respondent to rate the current testing system from one start to five stars. From the picture above, it can be seen that most respondents rated three
stars. Whereas, none gave five stars to the current testing system, which illustrates that employees are not satisfied with the current testing system.

6. List the tools you are using for testing in the company?

![Testing tools used in the company.](image)

The ambition of this question was to know about the testing tools used by employees. Respondents answered with both software and hardware tools used for the testing process in the company. Among 16 respondents, only nine responded to this question. The reason for this might be because not everyone in the company gets involved in testing. From the respondent’s answer, it is concluded that various software tools like Jira, PTT applications; and different hardware tools such as an oscilloscope, multi-meter, spectrum analyser, battery capacity tester, audio spectrum tester, mobile devices, and AINA accessories are used for testing.

7. An idea on how the company can improve the current testing system.
The above open-ended question was asked to know any possible idea for refining the company’s existing testing system from the employee’s point of view. Most of the respondents suggested for more automation, the addition of resources, better test cases, and more organised systems. However, a particular respondent suggested setting up a test management system for better testing, reporting, and proper identification.

8. Is it necessary to have a Test Management System in the company?

Figure 14. The idea for improving the current testing system.

Figure 15. The necessity of Test Management System in the company.
The above vertical bar chart represents the answer to the question which asked respondents whether it is necessary to have a TMS in the company or not. Majority of the respondents agreed that it might be essential to have a TMS in the company. Likewise, five respondents sharply answered “yes” to this question, which reflects the need for a TMS in the company. While no one from the respondents picked an answer as “no”.

9. What would be the requirements for the optimum Test Management System (TMS) for the company?

![Figure 16. Requirements for optimum TMS.](image)

Above figure demonstrates the answer to the question which requested respondents for the requirements for optimum TMS for the company. Average responses were to have automated and regression testing with well-sorted as well as regular test reports, including every detail. Other respondents wanted to have appropriate requirements, test status tracking, and a system that is easy to use and maintain.

10. Have you used any testing tool/s in your life? If yes, name them.
Figure 17. Testing tools used by respondents.

The tenth question prompt the respondents to answer any testing tool used by them until now. This question was quite familiar with question number 6, besides focusing more on software testing tools. Quite many respondents answered “no” to the query which may be because of not being involved in software testing. The one who is involved in software testing responded that they had used TestLink, JIRA, polariton, Trac, Bugzilla, test stand, JTAG, logic analyser, spectrum analyser, and Lint till now.

11. List important features a new testing system should have for the company.
Figure 18. Important features for a new system.

Above screenshot shows that the feedback to this question was similar to the answer to question number 9. The response reflects that the respondents want the system to have features like an automated test, regression test, flexible test plan, excellent tracking system, and detailed and understandable reports.

12. Any suggestion for a suitable testing tool for the company? Explain why.

Figure 19. Suggestions from respondents for an optimum testing tool.

The researcher wanted to know if there were any suggestions on the testing tool the respondents already knew which is appropriate for the company through this question.
Only one respondent answered with a link which consists of a few top testing tools. Thus, it illustrates that respondents have not much idea on an ideal testing tool for the company.

13. Any comments.

<table>
<thead>
<tr>
<th>Any comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Answers</td>
</tr>
<tr>
<td>Good work so far!</td>
</tr>
<tr>
<td>Thanks for spending the time on doing this for AINA.</td>
</tr>
<tr>
<td>no</td>
</tr>
</tbody>
</table>

Figure 20. Comments from respondents.

The purpose of this last query was to know if there were anything respondents wanted to share. Most of the respondents did not have anything to say. Few showed how happy they were with researchers work through their answers.

Overall, the survey findings suggest that the respondents (company workers) were unsatisfied with the existing testing system and wanted some improvement in the system. The responses reflect that having a proper TMS is a better idea for the growth of the system. Similarly, most of the respondents agreed that building a TMS in the company is necessary for better testing, reporting and proper identification of test. Almost everyone expected automated and regression as a significant feature in the new system. Moreover, respondents wanted a method to have a flexible test plan, excellent tracking feature, simple and easy interface, web-based application and well-structured clear reports.

In conclusion, the output of the survey helped a lot in deciding which test tool could be better for the company that meets all requirements of the company such that workers current testing process is benefited. Likewise, all the outputs gathered from informal interviews, discussions, and the survey was taken into consideration while constructing the optimum system.
4 AN OPTIMUM TEST MANAGEMENT SYSTEM

4.1 Current Testing Process of the Case Company

As the company has its own PTT devices compatible with both iOS and Android smartphones additionally with various PTT applications, its main target is to take its products all around the world offering next-generation Bluetooth speaker-microphone for better communication. Fundamentally, the testing process begins from test plan and control, analysis and design, implementation and execution, evaluating exit criteria and reporting, and finally test closure activities. In the commissioning company, test plans are initially made by QA and testing manager according to the customer’s need. These plans may alter according to the circumstances and customers requirements. The software developer develops or modifies the software according to the need. In expansion, software tester tests the customer’s PTT applications with AINA products and AINA applications. For the most part, the testing manager is in charge of overseeing these activities and checking them throughout the testing process.

The company does not have any written testing process, and this circumstance will continue even after having a test management system. The company also does not have any requirements management process, but in future, they might introduce requirement management inside the company. The company comprises of one testing schedule file, one testing folder storing all testing files and one software folder putting away software release files. All these files are stockpiled in google drive and shared with everyone through company email. The testing schedule file is an excel file that tracks test runs and incorporates subtle elements such as released software version, starting date, deadline, tested applications, AINA devices, tester names, test equipment, and tasks. Comparatively, the testing folder consists of all testing files along with test reports, test specifications, and templates. These testing files are arranged concerning the software release version and usually created in excel. They contain test cases, test results, details of tested applications and devices, and the summary. Moreover, software release folder covers all the released versions of software for different AINA products and applications. All the mentioned files and folders are testing documents of the company.

In the beginning, the customer’s requirements are noted down, and changes in the test plan are made. According to the customer’s need, tasks are created by testing manager
inside the testing schedule, including deadline, task details, specific application, AINA devices, and lastly assigned to different roles. In some cases, tasks are created as a result of internal needs and these domestic needs are linked with the customer directly or indirectly. As soon as the job is assigned, the software developer and the software tester begin working on it. The task with high importance is performed without any delay. Testers perform the testing and results are kept in excel file together with all details. After all test cases are performed with all testing devices and applications in any software version, the summary is drawn out. Then, the summary and a complete report are viewed by the project manager and the software developer for further analysis. If all the test cases pass, then the test plan is closed, and everything is reported to the customer for further utilisation of AINA product. Else, the software developer tries to fix bugs in the software. After every alters in software, a new version is released, and the same testing is repeated with the latest release. If there is any problem with the customer's application, and the company cannot do anything about it, then the company requests the customer to fix the problem. The company redoes the test after the customer settles the issue. This cycle goes on until all test cases pass. After all the test cases pass in any version of the software, it is considered to be the final version for end-users use until an overhaul is made. As time goes on, different updates are required in the software or the hardware. When there is an apprise in the software or the device, the testing process is once more rehashed within the company.

Through observation and process mapping, it can be seen that the central testing artifact in the case organisation is a folder with test specification. A test specification is an excel file which consists of numerous test cases with every detail of the testing environment and devices involved in testing. The current testing process of the company uses excel for test management, which is not the right approach since excel was never destined for test management. On the one hand, excel has always been effortlessly available, simple to set up, and easy to utilise. On the other hand, using excel for test management, documentation and reporting on testing activities can be amazingly awkward, wasteful, time-consuming and at times, disappointing process. Taking after are a few significant issues of excel for test management. (Gusmus, 2016)

- It required a considerable number of excel sheets.
- It is troublesome updating test cases in excel sheets.
- There is always inconsistent information in an excel sheet.
- Collaborating on excel sheets is difficult and artifact time-consuming.
➢ It does not support agile business practices.
➢ It is problematic to scale and consolidate in excel.
➢ Getting accurate insights is tough.
➢ It lacks centralisation.

During the case project, it was noted that the case organisation has to update test cases time and again for any change in the software or the customers. Also, the above issues overrun projects and delay the release of product because of supplementary micromanaging, follow up, data entry responsibilities or clean up activities which are not calculated as testing time. In addition, the intense timeline for testing puts weights on to get it right the very foremost time helping merchantable software to be discharged inside the strict deadlines. The combinations of the interviews, the survey, and the observations show that there is need of improvement in the existing testing system and having a test management tool in the company can enhance current challenges supporting automation and regression testing. Hence, it can be concluded that a test management system with the right tool is required in the company to draw the correct results on time. (ReQtest, 2018)

4.2 Selecting an Optimum Test Management Tool for the case company

This research aims to choose and set up an optimum test management system for the company, which is simple to use and uncomplicated to set up. To establish criteria for evaluation, desired features and other considerations were gathered from the interviews, the discussions with workers, the survey and the observations. From the collected features and concerns, the evaluation of different testing tool was done by the researcher. The link provided by the survey respondent was also taken into consideration.

Like many evaluation processes, the first phase in case project incorporated an underlying examination of all the tools to get a general thought of the highlights and possible limitations that would discount them from assessment rapidly. The aggregate of 50 tools was thought about. Every iteration ended with a review, and a portion of the competitors was removed from the list of considered tools based on findings. Although a large number of tools may have had a few highlights to satisfy the necessities of the organization, the particular usage of them were viewed as lacking.
In the second phase, six tools were pre-chosen for further detail evaluation after theoretical research was finished. Company requirements like web-based application, integration with JIRA, Redmine and Git, filtration feature, customisation feature, and user-friendly interface were contemplated while pre-selecting tools. Every pre-selected tools included necessary components for test and defect management and also provided means to have connections between different test assets. The further evaluation of pre-chosen tools was done in the third phase by utilising the vendor webpages to acquire the principle features and using trial versions of the tools. A small-scale rollout of the procedure was led on each tool to get some involvement in its usage. This empowered the researcher to identify further adjustment needed to the proceedings and the tool refining the estimation for the actual expense and benefits for the implementation (Hass, 2008). A feature monitoring and scheduling testing effort was investigated in each tool to validate that the tools truly has the functionality to allocate tests to users and to see the progress of testing.

During the evaluation phase, it was encountered that ‘TestRail’ have limited reporting function and some problem in collaboration. Furthermore, there was some issue with JIRA combination a couple of times, and, the system execution was weak as well as moderate in ‘TestRail’. In like manner, the requirements between ‘qTest’ and Jira did not synchronise a couple of times properly. Similarly, a few issues were found with ‘ReQTest’ when running in Internet Explorer. It was also comprehended that ‘ReQTest’ was somewhat hard to master and control. Moreover, ‘ReQTest’ does not have a tree structure in the test cases or better identification of objects and flexible customisation function. Correspondingly, reporting modules in ‘PractiTest’ have comparatively fewer features, and it is not an open source. Furthermore, ‘LambdaTest’ additionally shifted its performance on different browsers, and it has restricted concurrent sessions. Above all, ‘TestLink’ appear to oversee various labels of the case company testing, which was one of the challenges in creating a testing system. ‘TestLink’ also has some drawback; however, these downsides don’t appear to hamper the testing process of the commissioning company at the present phase and even in the near future. Therefore, ‘TestRail’, ‘qTest’ and ‘ReQTest’ were wiped out considering the drawback observed from testing in a pilot environment.
Now, the cost was thought about in the fourth phase. The chart underneath demonstrates the total cost of using each pre-chosen tool for the case company every year. The expense of utilising ‘PractiTest’ and ‘TestRail’ is by all accounts over the top expensive, so these were eliminated later. Whereas, the cost of other pre-selected tools varied a fair amount. Comparing all pre-chosen tools, ‘TestLink’ is a free open source web-based test management tool. Finally, ‘TestLink’ was taken into consideration based on established criteria, cost, and functionality.

Due to the iterative and excluding nature of the evaluation, not all tools were assessed at a similar degree. The underlying criteria developed a little through the commissioning company; however, the ideal functionality stayed all through the entire task. Also, the manner the assessment was done depended highly on information gathering and evaluation done by the author. Therefore, the evaluation made in this study might be regarded as highly subjective, possibly reducing the credibility of the result.

4.3 TestLink Overview

TestLink is a standout amongst the most extensively used web-based open source test management system(tool) developed and kept alive by Teamtest that aids software
quality assurance (Encyclopedia, 2018). The records of all STLC stages beginning from
the test project to the report creation stage are tracked and maintained by TestLink. It is
a PHP based application which supports all OS platforms such as Windows, Mac, Linux
of different versions; and all popular browsers like Chrome, IE, Mozilla, and Safari. It
offers back for test projects, test plans, test specifications, test suites, test cases, user
management and various reports and measurements. (Wikipedia, 2018) (Tutorialspoint,
2019)

Test projects, the basic unit of TestLink, are typically products or solutions of the
association, which will alter their highlights and usefulness over time. It incorporates
requirements documents, test plans, test specifications and user rights. They are
independent, so they do not share data. (Wikipedia, 2018)

Test plans are the primary document created during an early phase of the project for
executing a set of tests on an application. Each test plan belongs to the current test
project. They include builds, milestones, user assignment, chosen test cases from test
specification, priority definition and test results in TestLink. (Wikipedia, 2018)

Test specifications are one of the element of TestLink which contains all components,
categories and test cases within a project. Each test project has a unique test
specification. Each test specification is further broken down into test suites, and test
cases and these levels are held on throughout the application. (Wikipedia, 2018)

Test cases are the critical piece of TestLink organised in test suites. They are a simple
task in the workflow of an application. It has different parts like title, summary, steps,
expected results, attachments, importance, execution type, and custom fields.
(Wikipedia, 2018)
Every testing user has a Role that defines available TestLink features. The default types of user roles in TestLink are Administrator, Test Lead, Test Analyst, Test Designer, Test Executor (who can execute only assigned test cases), and Guest. The administrator role is responsible for the whole management system, Test Analyst has significant rights in test project management, Test Lead has more authority than test analyst, Test Designer can create, delete and edit test cases and test suites, Test Executor can execute only assigned test cases and Guest can see all the information but cannot edit. In addition, custom roles can be created when necessary. Figure 22 demonstrates the functionality workflow of testing according to users roles. (Wikipedia, 2018)
Features of TestLink

TestLink encompasses a vast extent of highlights to draw in QAs and other partners for test administration. It also bolsters both unique test strategies such as agile testing, exploratory testing, black box testing, traditional testing and functionality/manual and automation testing. It creates, centralises, organises and manages test cases very effectively and efficiently. It manages and tracks test execution supporting multiple reports. It even promotes customisation of UI using Smarty templates. Some of its features are listed below.

- It is easy to learn and reliable.
- It supports multiple projects.
- It has a user-friendly interface with easy export and import of test cases.
- Automated test cases execution is through XML-RPC.
- It has straightforward filtration of test cases with version, keywords, test case ID and version.
- It has features to prioritise testing and assign a test case to multiple users.
- It has a smooth process to generate a test plan.
- It creates test reports in various formats.
- It provides credentials to multiple users with defined roles, and all can access functionality at the same time.
- It supports integration with many popular defect tracking systems such as TRAC, JIRA, MANTIS, Bugzilla, VersionOne, FogBugz.
- It is regularly updating and suit to the new test trends.

4.4 Testlink set up for the commissioning company

Based on the evaluation in previous phases, TestLink was believed to be the ideal tool among the commercial tools against the criteria. After the selection of the tool, the real challenge was to make it a piece of regular daily existence in the commissioning company and to keep it alive long enough to profit on the investment (Hass, 2008).

In the beginning, TestLink 1.9.18 was installed in localhost by the researcher to perform a pilot project during the evaluation phase. There were some adjustments done to make the tool comply entirely to the processes of using the tool as it is. After the selection of
the tool, TestLink 1.9.19 was installed. There was not much difference between these two versions. The set up of a testing system for commissioning company was done carefully step by step. Only the test cases were transferred from old version to new version. During the installation of TestLink, the primary user (admin) was created. Most of the set up was done by using the admin role.

Figure 23. Main dashboard of TestLink.

The main dashboard of TestLink set up from admin page for the commissioning company is shown in Figure 23. After logging inside the TestLink, different users were created for the test team of the case company inside the ‘User Management’ tab. Few manual role permissions were changed as per the company need. Similarly, all the available test phones were added inside the ‘Platform Management’ tab. These phones are assigned to test plans for test execution during testing. Consequently, various custom fields were created inside ‘Define Custom Field’ tab, which is assigned to test cases as per the need of test project during testing. In like manner, useful keywords were added inside the ‘Keyword Management’ tab. These keywords are assigned to test plan and test cases for smooth filtration. Moreover, various test projects were created from the ‘Test Project Management’ tab. Under every test project, various test plans were created from the ‘Test Plan Management’ tab describing the goal of the test cases execution, its execution, and strategy. Likewise, inside all test plan, builds were created from the ‘Builds / Release’ tab as every test plan must have a build associated with being able to be executed. The AINA software version was considered as the build for the optimum
system. For example, the build for every test plan related only with APTT was APTT software version, the build for every test plan related only with ASB was ASB software version, and the build for every test plan related with AINA Connected was also its software version. Similarly, inside ‘Test Specification’ tab of every test plan, related test suites and test cases were created. Every test case contained suitable custom fields, platforms and keywords. Later several test cases were executed in every test project, and test reports were received from ‘Test Reports and Metrics’.

The set up of the current testing system into TestLink was done in a delicate way such that the system includes every aspects and label of the commissioning company with useful test reports. The company has many labels that vary with respect to the test plan, and including every phase in the test plan was one of the main challenges for the researcher. As the company has various products, the test projects were mostly considered to be the products. Under every test project, many test plans were created associated. These test plans varied concerning the product or test project. For examples, test plans for ‘APTT testing’ and ‘ASB testing’ test projects were considered to be the PTT application along with the testing is done and ‘AINA Connected Testing’ test project was considered to be the company PTT devices.
To clarify, the testing hierarchy of the case company is presented in Figure 24, where red colour boxes represent ‘Test Projects'; and green and purple boxes represent ‘Test Plans'.

Figure 24. Testing hierarchy of AINA Wireless Ltd.

Figure 25. List of Custom field, Keywords and Platforms of TestPlan.
In addition, the test projects consist of one test specification which enclosed all the test suites and test cases within the test project. Further, the test plans contain their test cases, test suites, custom fields, keywords, platforms and builds. To demonstrate, the list of custom fields, platforms and keywords which are included in test cases and test plans of the case company Figure 25 is placed above. The boxes with dots ‘...’ seen in pictures 25 and 26 represent that there are many more test plans, platform, and keywords respectively, which were not possible to be shown.

![Figure 26. Overall metric in pie-chart inside TestLink.](image)

Test cases were executed for every single test plan to receive test reports. Likewise, the reports were generated in various formats. It was also possible to create reports for any specific platform and build. Similarly, test reports of either failed or blocked, or not-run test cases were also available inside the system. As an illustration, Figure 26 represents the overall metric of the commissioning company in pie-chart format.

During the set up of the new testing system inTestLink ‘Requirement Management’ tab was not used because the company does not have any requirement management process at present. In the future, it was discussed that the ‘Requirement Management’ tab would be used when necessary.
4.5 Comparison of the old and new testing system

The potential internally developed solution based on the excel files was compared against the system built in TestLink for various reasons. The company wanted to know how the current system would fare from the TestLink and what effort would be required to get the tool developed. From the comparison of these two systems, the company would decide whether or not to implement the new system in the coming days.

Table 1: Evaluation of the old and new system according to ISO/IEC 25010 standards

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Old testing system</th>
<th>New testing system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functional suitability</td>
<td>Fair</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Reliability</td>
<td>Good</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Performance efficiency</td>
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<td>Satisfactory</td>
</tr>
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<td>Satisfactory</td>
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<td>Satisfactory</td>
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<tr>
<td>Maintainability</td>
<td>Fair</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Portability</td>
<td>Good</td>
<td>Satisfactory</td>
</tr>
</tbody>
</table>

The comparison of two systems was made based on ISO/IEC 25020 system and software standards, and it is presented in table 1. The estimation was made using scale ‘fair’, ‘good’ and ‘satisfactory’. Test team of the case company were involved during the comparison of the testing systems. The old system represented the system which exists before the study, whereas the new system served the testing environment set up in TestLink. From table 1, it can be noted that the old system has more limitations. Whereas, the new system fulfilled every essential criterion the company wanted to have, and the scale for it is ‘satisfactory’ in every category. There were many improvements in test cases and test plans of the company during this study, which also lead the new system to be more suitable for the company. Therefore, it was decided to implement TestLink in the company and continue the improvements in future.

To emphasise, it should be well-known that the tool is not a miracle solution, and it should be put under proper configuration just like the rest of the test environment. Furthermore, it is fundamental to supply suitable training for the test team to utilise the method before
implementing it in the company. It is also vital that the progress is monitored and management is briefed frequently about achievement and success, such that the benefits of introducing the process can be qualified and remodelled. (Watkins, 2004)
5 CONCLUSION

The principal aim of this research was to develop an optimum test management system which addresses the current problem and fulfils the desired criteria of the commissioning company. This was achieved by gaining theoretical knowledge on the topic, examining the ongoing testing process, selecting a suitable test management tool, and finally building the system in the chosen tool.

Before starting the practical work, theoretical knowledge was gained by the self-learning process on the related topics. The analysis of the current system was carried out by being involved in the testing process, gathering information and having regular discussion with the testing team. Few informal interviews and a survey were conducted to find out the challenges faced by workers using the current system and to know the desired criteria needed in the new system. It was revealed that the workers were facing many difficulties with the current testing system, and they were hoping to have a test management system with more automation available. After studying 50 different tools, TestLink was selected as a test management tool for the company. Later, the testing environment was set up, which was easy to use and implement. Lastly, the evaluation was made between the old and new system for further decision-making. After the review, it was found that the new system established in TestLink was better than the old system. As a result, it was decided to implement the new system in the commissioning company and continue its further improvement shortly.

Based on experience gained from the thesis work, it is clear that testing is a must process in SDLC and the key to effective testing is by making the process as efficient as possible with rigorous planning, well-managed project management, a capable test team, and by utilising the benefits of a testing tool.

Going forward in time, if the commissioning company wants to improve the new system further, it is recommended they study the new testing strategy in detail. The study of the new system can be conducted after some time of the implementation. More development can be carried out in areas such as test cases, test plans, how to effectively manage test automation, and how to make maximum utilisation of the tool.
REFERENCES


