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TESTING OF A BASE STATION SOFTWARE RELEASE

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ABSTRACT

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This thesis is written in a diary format, and it focuses on testing of a base station software release. The goal of this thesis is to explain the testing process of one such release. The work for this thesis was done in Nokia Home of Radio which is located in Oulu.

This diary goes through the daily work of a test engineer. The author of this thesis will go through the testing process for this particular software release. This process is reported with short daily reports and with weekly analyses.

At the end of this thesis there will be a conclusion that includes my final thoughts about this thesis and the work that was put into it.

Keywords: 5G, Mobile Network, Cloud, CU, DU, Base Transceiver Station, performance testing, Diary

CONTENTS

TERMS AND ABBREVIATIONS

5G	fifth generation of wireless communication technology
BTS	base station
Throughput	the rate at which data is being successfully transmitted.
Jira	project management and issue tracking software
SW	SW is an abbreviation for software.
Scrum	Widely used framework for managing and organizing complex projects.
RAN	Radio Access Network, refers to the part of a mobile network that connects mobile devices to the core network and the broader internet.
BBU	Baseband Unit, fundamental component of the radio access network infrastructure. BBU is responsible for handling the digital processing of the wireless signal.
DU	Distributed Unit, component of the radio access network architecture. DU is responsible for processing radio signals and managing the radio resources for a specific geographical area.
CU	Centralized Unit, component of the radio access network architecture. CU is responsible for higher-level functions in the radio access network, often involving coordination, control and management of multiple DU units.
SA	A mode of deployment where the 5G network operates independently of 4G.
NSA	A mode of deployment where the 5G network relies on existing 4G infrastructure for critical functions.

1 INTRODUCTION

This thesis uses a diary format to document the process of testing a software release for Nokia. The primary objective of this thesis is to provide insights into the daily work of a test engineer and to show what kind of obstacles and challenges engineers tackle on a daily basis while performing their testing duties. The diary takes place between 8th of May and 16th of June in 2023. In the diary there is a small summary of the tasks accomplished each day and an analysis of the progress for each week.

The client of this thesis is Nokia Solutions and Networks Oy. While Nokia operates from various locations in Finland, this particular thesis focuses on the Nokia Oulu office, also known as the Home of Radio.

Nokia is a worldwide telecommunications company that is widely recognized for its historical presence in the mobile phone industry. However, nowadays Nokia is focusing on development of 5G networks and doing so they are one of the leading companies on their field. (1).

2 BACKGROUND

This thesis goes through the testing process of a software release for cloud base transceiver station (BTS). The typical tests can be categorized into three primary types: new feature testing, regression testing and stability testing. The main focus of this thesis is on the testing of new features. While testing new features, whenever a fresh addition is incorporated into the software, certain dedicated tests must be conducted to guarantee the software's quality. These tests are so called feature specific test cases. However, in more general sense, all the test cases can be categorized into these key groups: throughput testing, user amount testing, traffic model testing and stability testing. Each of these tests are designed with a specific goal in mind. In all of these tests there are also preconditions that have to be followed. By following these conditions, the testcases are executed. During this process if any faults or issues are discovered those need to be investigated and fixed.

In throughput testing there usually is a set number of users that needs to be connected at the same time. With these users a set amount of throughput must be reached. These user amounts can vary from just a couple of users all the way up to multiple thousands of users. The target for user amount and throughput for these cases might change between different test lines because of different hardware limitations. In user amount testing the goal is to get a set number of users to connect at the same time. Usually this means the maximum amount that the hardware can support. With these tests there might not be any throughput involved. Traffic model testing focuses on simulating a real-life scenario. The goal is to simulate a steady flow of traffic, so basically there is constantly new users connecting and old users disconnecting. These users might transfer data while connected but not always. The stability testing focuses on the overall stability of the test line. Usually these tests are run on a similar traffic as the traffic model cases but the goal in these is to run the test from 2 hours all the way up to 120 hours. During these stability runs there cannot be any issues or the test cannot be passed.

Mobile network can be split into 3 different parts. These parts are User Equipment (UE), Radio Access Network (RAN) and Core Network (CN). User equipment can be a mobile phone or any other device that is connected to the mobile network. RAN is the part of the network that connects individual devices to other parts of the network through a radio link. RAN consists of radios, antennas and baseband units (BBU) or in cloud environments CU and DU. The core network is the final

part of the mobile network. Its jobs are for example, to connect users to different networks, authentication of the users and handling the billing of the users. (2, 3.)

The cloud BTS software consists of two different pieces. Centralized Unit (CU) and Distributed Unit software. In this thesis the used test line is somewhat special in a sense that it only uses the CU SW. Because of that the testing is focused on Capacity and Performance testing of the CU SW. This test line can also easily be changed between stand-alone (SA) and non-stand-alone (NSA) which expands the possibilities for various tests. This test line is controlled with two control PCs. Control PC 1 is used to control the UE simulator. With this PC it is possible to control what kind of traffic is simulated. The control PC 2 is mostly used just to update the CU SW but It can also be used for log collection directly from the CU. Also, all of the tests are conducted in a laboratory environment, so the data is not transmitted over the air. The configuration of the test line used in this thesis can be seen in figure 1.

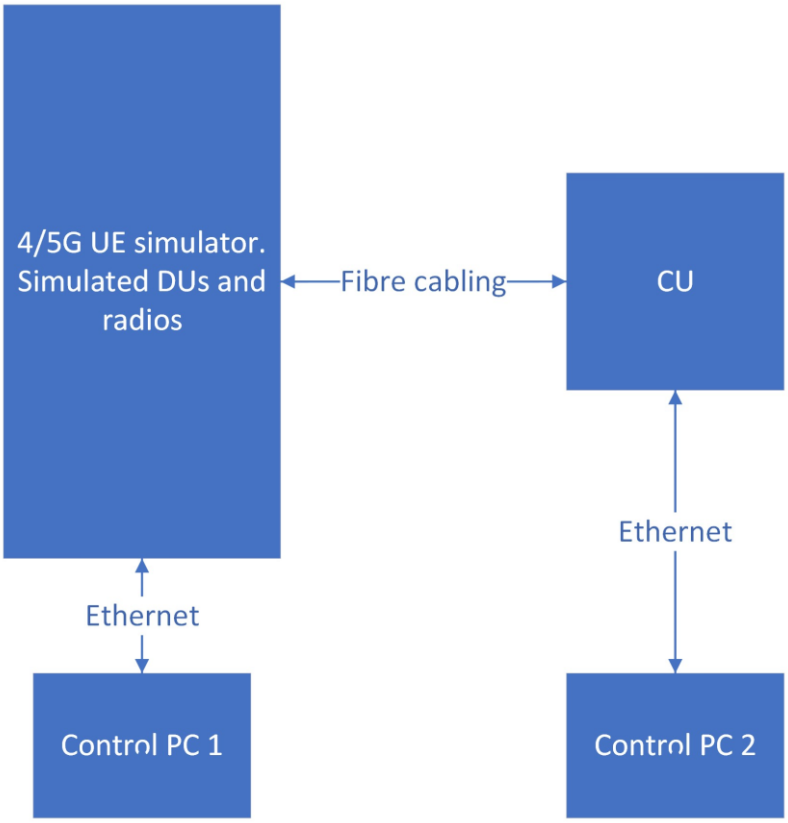

FIGURE 1. Simplified picture of the test line used in testing for this thesis.

CU is a vital component of the 5G network infrastructure, responsible for overseeing and managing various aspects of the network's operations. It handles resource allocation, coordination, mobility management and setting up connections. Whilst CU does all that, DU is responsible for radio-

specific functions and physical layer processing. It manages tasks such as radio signal coding and decoding, radio resource allocation and low latency processing. (4, 5.)

Test engineer's primary responsibility is to find possible faults in the 5G base station software and report them forward. These issues are solved by working in cooperation with different SW teams around the world. Also, the test engineer's personal test line must be kept up to date and functioning at high level with newest SW releases and functionalities.

Issues found during testing are reported in Nokia's internal fault reporting tool. For each found fault or issue a new report is created. These fault reports are investigated by software teams all around the globe to find the root cause for these issues and to fix them. This fixing process might take multiple weeks to complete depending on the root cause. The fixing process usually starts with investigation phase during which the tester might need to collect additional logs for better understanding of the issue. After the root cause is identified the correction phase begins. During this phase the issue is being fixed and tested with experimental software to see if the fix is working as intended. After the correction is ready and tested, it can be released into the official software.

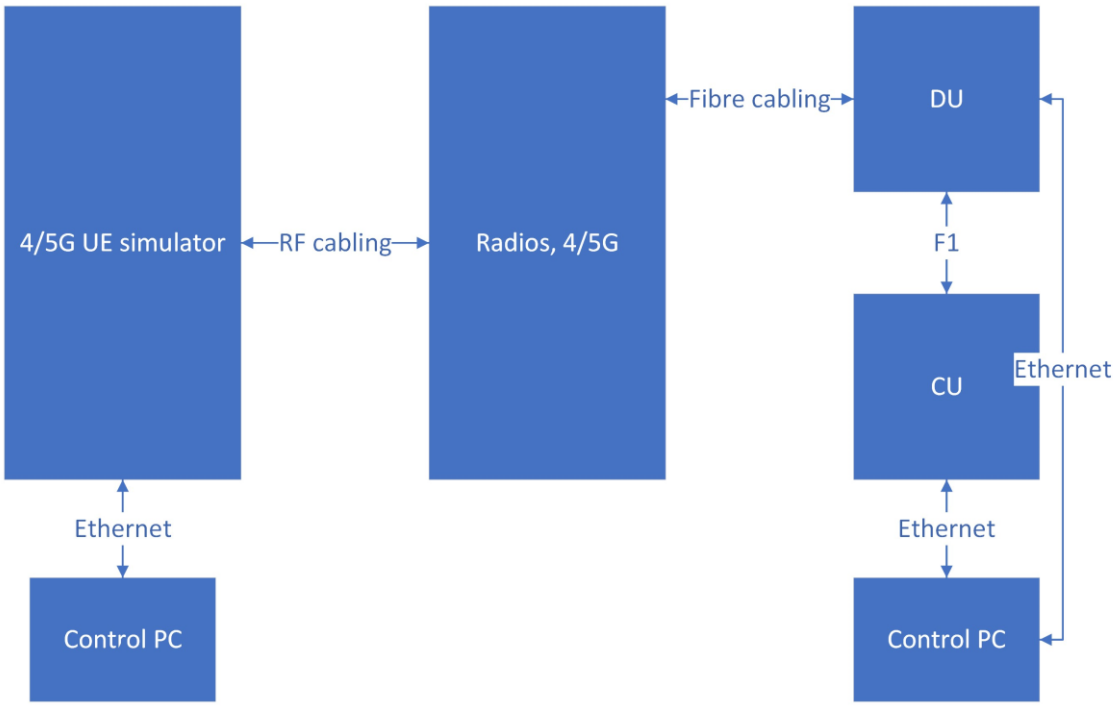

FIGURE 2. Simplified picture of Cloud BTS test environment. (6).

The difference between cloud BTS and classical BTS is the fact that in cloud environments the RAN hardware and software are disaggregated. For example, in classical environment the base-band unit (BBU) is a physical hardware but in cloud configuration it is replaced with a software running as containers inside a Linux server. In cloud the BBU is split into DU and CU. Because DU and CU are not physical hardware, they can be located closer to the core network. Which leads to the maintenance cost of cell sites to go down. Differences can be seen in figures 2 and 3.

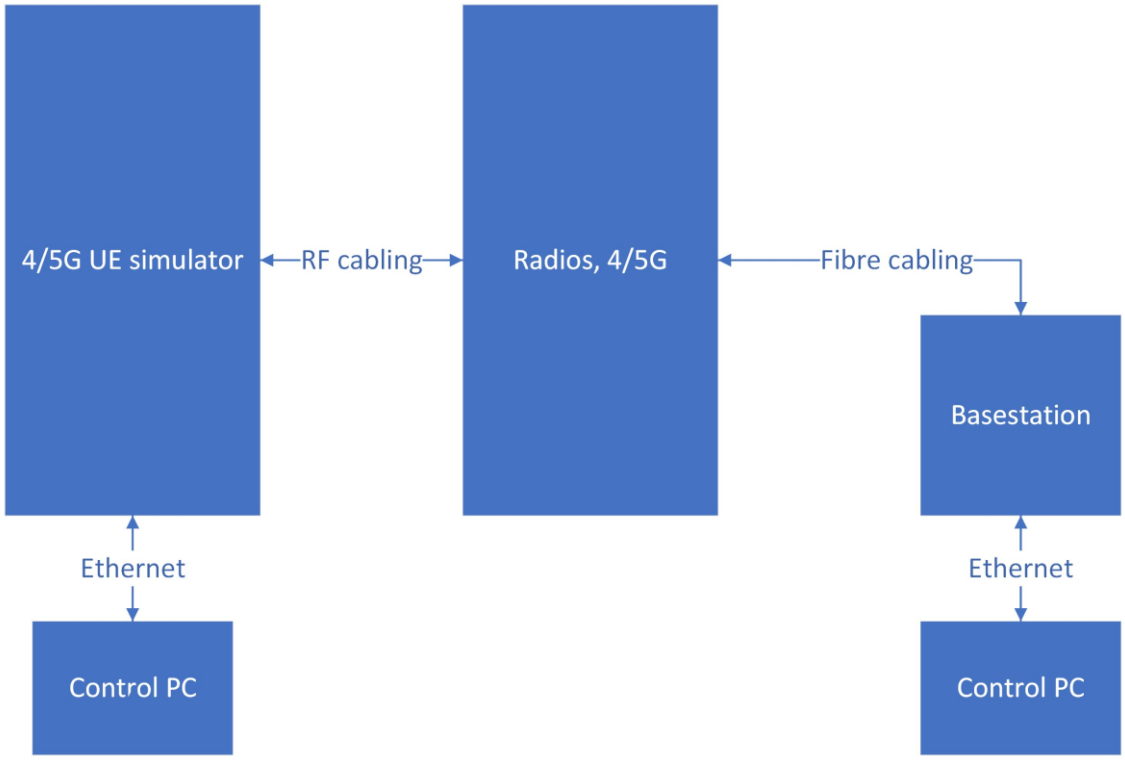

FIGURE 3. Simplified picture of typical classical BTS test environment

Testing teams use somewhat applied Scrum project development methodology. Team meetings are held every morning and during these meetings individual progress from the previous day is reviewed and discussed. (7). Most testing hours are tracked using Jira. In Jira, each test engineer is assigned specific tasks, enabling engineers to monitor the time dedicated to different aspects of the testing process. (8).

3 TEST PLANNING AND EXECUTION

The testing done in this thesis is performance testing. Each release starts with figuring out what type of test environments are needed for this release based on the requirements set by the features in this release. The next step is to identify the performance metrics that need to be reached. After these steps the planning and designing of the testcases itself can begin. Each testcase is designed to test different things and they all have different variables and targets. Once the test planning is finished, they are reviewed and given to the test engineer. When the test engineer has the planned cases, they can begin setting up their test environment to start testing. Usually, the execution order of the tests is up to the test engineer. Sometimes some of the new feature cases must be tested first but usually there is no set order. After each testcase is tested needed logs must be collected and the results analyzed to see if targets for each testcase are reached. All this is visualized in figure 4. (9).

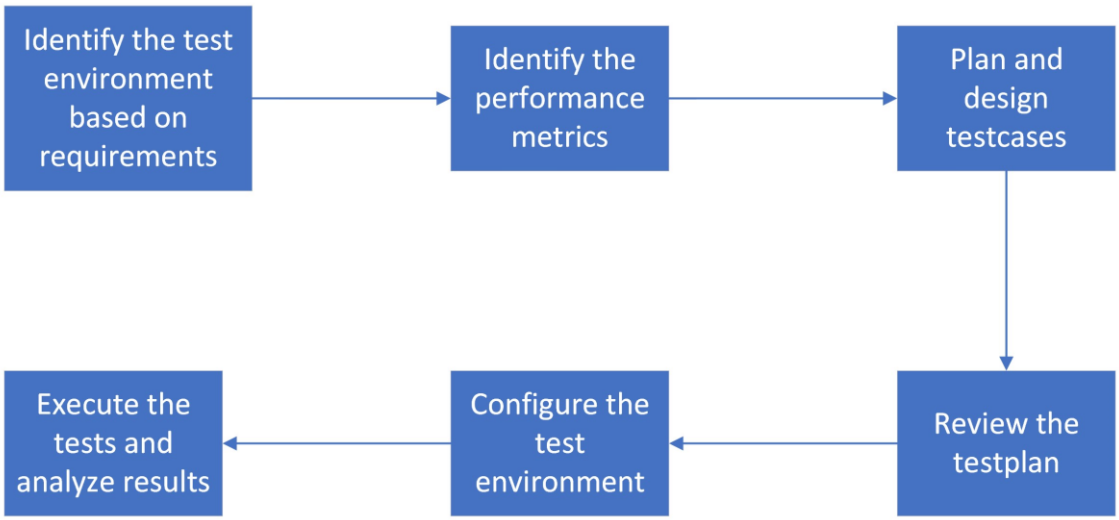

FIGURE 4. Basic flow of performance testing. (9).

Usually, each testing team has at least one dedicated person to do the test planning. For each feature there is usually a few testcases strictly designed to test the contents of this feature. These testcases can be designed to just test the integrity of the software after the feature is added or they might be more specific for example if the new feature includes a new functionality, there might be a testcase just to test that. Usually there is also more traditional testcases that focus on testing throughput or user amounts to see if the addition of the feature has had an impact in performance. The test engineer itself does not really participate in planning these testcases. Only once the cases

are ready are they reviewed by the test engineer just to make sure that there are not any obvious mistakes in the plans.

The plan for this thesis is to start testing with throughput testcases, then move to the traffic model and stability testing and finish with the user amount tests. Hopefully all the testcases can get tested in the next six weeks, before the summer vacation period starts. Because of this time limitation, for each type of tests there is approximately two weeks time to complete the tests, but this might change if any issues are found because the fixing process of these issues sometimes takes a long time.

4 DIARY

4.1 Week 19

Monday 8.5.2023

Testing of the next release is scheduled to begin this week. Preparations for this were initiated a few weeks ago. However, the final preparations are still in progress. The test line is already prepared, but permission to commence testing is still pending from our team's technical leader. Permission has not been granted yet because the software is not quite ready. Meanwhile, test automation has been tested to make sure that it is working as intended.

Tuesday 9.5.2023

Final implementations to the software are expected to be completed today, and as a result, permission has been granted to commence testing tomorrow. Today's plan includes conducting additional test automation runs and making final preparations for tomorrow. The test cases have been reviewed, and the order in which the tests will be run has been planned.

Wednesday 10.5.2023

Testing was initiated today as per the plan. The decision was made to begin with throughput testing because there were some matters that needed to be addressed before other test cases could be started. Following the latest upgrades to my test line, throughput testing progressed smoothly, yielding positive results, and two test cases were successfully passed.

Thursday 11.5.2023

Continued with the throughput testing. Good results were achieved, but discussions need to be held with the technical leader regarding the results and the possibility of pushing the test line for even better results.

Friday 12.5.2023

A discussion was held with the technical leader about the results, and it was decided that a different approach should be tried with the test case. After some modifications were made to the test case, the results began to improve. Due to running out of time, testing for this case will need to be continued next week.

Weekly analysis

Testing started off great. Good progress was made this week. There have been no issues related to the throughput tests so far. The plan is to have all throughput cases tested next week.

4.2 Week 20

Monday 15.5.2023

Testing with the case that was run last Friday was continued. This time, even better results were achieved, and as a result, two more test cases were passed. The necessary modifications to the test line for the next test case were initiated. After the modifications were made, a couple of runs for the next case were performed, and the results were looking promising. Testing will be continued tomorrow.

Tuesday 16.5.2023

Testing was continued as planned but encountered some issues. It appears that once again, a change in the way the test will be executed is necessary. After a brief discussion with the team's technical leader, a new plan for the test case was formulated. Since it was already late, testing with the new plan will be initiated tomorrow.

Wednesday 17.5.2023

The test case was started according to the new plan from yesterday. Good results were being achieved. After some final changes to the test, satisfaction was reached with the results, and the test case was passed.

Thursday 18.5.2023

Public holiday.

Friday.19.5.2023

Today, preparations for traffic model test cases were initiated. Changes to the test line configuration and the update of the software to the newest available version were necessary. Following these adjustments, issues in the performance were identified. Logs concerning this issue were collected, and the investigation was commenced.

Weekly analysis

The week began with some difficulties, but in the end, it was nothing serious. Just some changes were required in the configuration, and it was working again. All the throughput cases were managed to be tested this week, and the transition to traffic model testing was possible. Performance issues were encountered when running the traffic model, and the investigation was initiated and will continue next week.

4.3 Week 21

Monday 22.5.2023

The issue from last Friday appears to be impacting another test line as well. The investigation was continued with the owner of that test line. Not many findings were made today, so efforts will need to be made to identify the software build on which this issue began to appear.

Tuesday 23.5.2023

Today, testing of other software builds was initiated with the hope of identifying the one where the issues began. This process occupied the entire day, but in the end, the precise build on which this issue began to manifest was determined. Now, the necessary logs need to be collected, and efforts will be made to ascertain the cause of this issue in order to create a fault report.

Wednesday 24.5.2023

The logs were collected from both the last working software build and the one with issues. An analysis of the logs was conducted, and a conclusion was reached regarding the type of fault report that should be created. At the end of the day, the report was created, and now the waiting for a response from the software developers has begun, along with the possibility of assisting them with additional log collection.

Thursday 25.5.2023

Today, an information request was received in response to the fault report. More logs with debug logs activated were requested. The collection of these logs and the answering of a few questions about the testcase that was being run were carried out. For the remainder of the day, traffic was run with the last software build that was functional.

Friday 25.5.2023

Today, no updates were received regarding the fault report. Traffic was run on the old software build to maintain the test line's activity. The remaining time was utilized to complete some internal trainings within Nokia.

Weekly analysis

The first fault report of the release was created this week. The beginning of the week was dedicated to the investigation of the identified issue, and upon the collection of the necessary logs, the fault report was created. There was no breakthrough in the report this week, but it is hoped that the investigation progresses swiftly in the coming week.

4.4 Week 22

Monday 29.5.2023

The logs were analyzed by software developers, and the error causing this issue was identified. This same issue had been previously discovered, and multiple fault reports had already been created regarding it. The report was grouped together with those existing reports, and a correction is expected to be released later today.

Tuesday 30.5.2023

The correction for the fault report was released last night, and testing was initiated this morning. The correction appears to have resolved the issue, but now performance issues have emerged. Further investigation will be required.

Wednesday. 31.5.2023

Performance issues persist. The issue was investigated today with the assistance of one of the team’s technical leaders, but no breakthrough was achieved. The logs were reviewed, but nothing

was found that could warrant the creation of a fault report. The investigation will need to be continued tomorrow with a newer software build.

Thursday. 1.5.2023
The investigation was continued today. More logs were collected with the newest software build, but the logs appeared the same as before. Nothing was found that would warrant the creation of a report. It seems that this investigation may need to be entrusted to our other test line, and I may need to proceed with testing other test cases.

Friday 2.5.2023
A successful test was run overnight, leading to the successful completion of two test cases. Preparation for the next phase of testing was also initiated. The descriptions for the user amount test cases were reviewed, but a discussion with the technical leader who designed these cases is still pending.

Weekly analysis
This week did not turn out to be as eventful as usually. Some cases were passed, which is a positive development. Despite the significant performance issues, some progress was made. The investigation of these issues was transferred to another test line, allowing this test line to concentrate on other test cases.

4.5 Week 23

Monday 5.6.2023
More information about the test cases was received, enabling testing to be initiated. The necessary changes to the test line were made, and a few test runs were conducted. During the process of making changes, an issue in the software was discovered, which likely needs to be addressed via a fault report.

Tuesday 6.6.2023
A discussion was held with the technical leader about the issue discovered yesterday. It was determined that a report needed to be created about it. All the necessary information was gathered,

and the report was created. Testing was continued, and it appeared that a hardware limit had been reached. Further discussions with technical leaders will be required to address this issue.

Wednesday 7.6.2023

The investigation of the fault report was initiated, and it appears that the fix should be fairly quick. Additionally, it was discovered that there was a limiter in the UE simulator, but a workaround was found to continue testing. However, even with the limiter deactivated, there were still difficulties in obtaining favorable results for the test case. Further investigation is needed to determine the cause of these issues.

Thursday 8.6.2023

A discussion about this issue was held with the technical leader, and initially, uncertainty existed regarding the cause. Additional logs were collected, and efforts were made to search for any useful information within them.

Friday 9.6.2023

No breakthrough was achieved with the logs. Testing was conducted with the newest available software, but the issue remained apparent. It may become necessary to seek assistance from the software developer teams to gain their insights into this issue.

Weekly analysis

This week, testing of the user amounts was initiated. A problem was encountered right away, but fortunately, it was quickly resolved through a fault report. Additionally, the presence of a limiter in my UE simulator, which was previously unknown, was discovered, which is a significant finding. Even after the limiter was adjusted, the desired results were not achieved, necessitating further investigation in the coming week. While there was not a substantial amount of progress this week, at least one issue was resolved, making it a week with some accomplishments.

4.6 Week 24

Monday 12.6.2023

A few ideas were suggested by the technical leader that we should attempt. However, in the end, there was no change in the final result, and the same issue persisted despite all the modifications. Tomorrow, assistance will be sought from the software developer team.

Tuesday.13.6.2023

The SW developers were contacted, and now all that can be done is to await their response and hope that they can find something useful in the logs. While the issue is under their investigation, traffic was being run to ensure there is no downtime with the test line.

Wednesday 14.6.2023

No findings have been reported by the SW developers yet. Testing was continued to maintain the test line's activity. Hopefully, more information will be obtained tomorrow.

Thursday 15.6.2023

No findings were reported by the SW developer team; however, something was discovered. With this finding, the fault report for this issue can finally be created, and the official investigation can commence. A collection of additional logs is needed, and tomorrow, the report should be able to be created.

Friday 16.6.2023

The report about the issue was created. There were no updates or questions received today. It is hoped that the investigation progresses quickly. While waiting for an update on the report, the decision was made to test some other test cases, but it appears that there might be issues in those as well. Further investigation will be necessary when more time is available.

Weekly analysis

The week commenced slowly, with few updates from the SW team. Towards the end of the week, a fault report about this issue was finally created. In terms of test cases, there was not much progress this week, but at least these issues were discovered. Following this week, the vacation period will begin, and the responsibility for this investigation will be transferred to someone else in the team.

CONCLUSION

Testing of this release went smoothly for the most part. I found a few quite big issues while testing and correcting those issues took a lot of time. Because of that I was not able to get all of the planned testcases tested and passed during this thesis. After the final week of the diary, I started my summer vacation, and the testing was left for other engineers in my team to finish. When I came back from my vacation all the tests were tested and passed and all of the found issues were fixed.

During this thesis I was able to deepen my understanding of the CU software and my personal test line. I got more familiar with some of the software components, and I got a lot of experience in testing in general. This was not my first release that I was testing so I did have quite a good foundation for testing, but while writing this thesis at the same time as testing the release, it helped me to dive deeper into the testing process and encouraged me to get more familiar with the software.

In the end, I did not quite reach the goal of this thesis which was to get all the testcases tested before my vacation. This was not possible because the issues that were found took longer to fix than anticipated. On the other hand, my primary job as a test engineer is to find these issues and to get them fixed, so I do not think of this as a complete failure. At least the possible customer is getting a better product because these issues were fixed.

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