Status Report for Implementation of a 5G Indoor Testbed with O-RAN and SDRs

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**Prepared by:**

**20123851 - Chris Escandor**

**14880978 - Edward Keith**

**21135280 - Kat Milicevic**

**21138990 - Samuel Cathro**

**21152433 - William Bigley**

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| V1.7 | 29/05/2024 | Edward Keith | Tech demonstration and troubleshooting expansion, screenshot evidence, overall document editing |
| V1.8 | 30/05/24 | Chris Escandor | Updated status progress, constraints and individual contributions |

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# Executive Summary

The progress shown in the Implementing a 4G Testbed with O-RAN and SDRs project thus far will demonstrate that we have successfully installed the srsRAN 4G library including srsENB, srsGNB, and srsGUI, as well as the UHD drivers and firmware necessary to run the Ettus Research USRP B-205 radio module. Despite various setbacks, the team has managed to install the software and its necessary dependencies, proving that we are on track to complete our final project deliverable of connecting two B205-mini modules to separate corresponding computer systems and using them to enable communication on a 4G network between two different mobile end devices.

# Project Description

# Our proposed project aims to emulate the implementation of an open-source 5G small cell base-station, leveraging Software Defined Radios (SDRs) and off-the-shelf hardware. The objective is to replicate the functionality described in the paper T ARXIV.ORG: 2205.13178, utilizing a standard laptop/PC and National Instrument B-205-mini SDR (Software Defined Radios) module with appropriate antennae.

# Project Brief

## Scope

The project scope encompasses the emulation of both RAN and mobile core network functionalities using open-source software and SDR technology. We will focus on developing software components that replicate the functions of proprietary hardware, ensuring compatibility with existing network infrastructures.

## Approach

Though our original project timeline somewhat underestimated the time that would be occupied by the startup and initial hardware configuration, our project’s objective is still to connect the necessary hardware, collect performance metrics, and provide documentation on all troubleshooting endeavors. Due to the technologically advanced nature of our project, we have had to dedicate much of our collective time to upskilling, including research.

## Major Milestones

* Project kick-off and planning
  + Throughout this stage collaboratively we defined the project goals, outline the scope and deliverables, and identified the key stake holders. We determined the required resources, identified the roles of team members, estimated the project budget, and identified the required tools and materials.
* Research and Requirements Gathering:
  + We conducted thorough research and on other projects with similar scopes. Conducted meetings with our mentor and stakeholders to identify what was required and outline the required brief. Once this was completed we undertook a feasibility study, to ensure that the project was viable.
* Upskilling
  + Once we identified the required tools to get the job done, we went about upskilling to fill in the skill gaps to ensure that we could undertake the project with minimal difficulties. We conducted training sessions together to teach other members of the group skills learnt to help fill in overlap.
* Development, Configuration, and hardware configuration and integration.
  + In this stage we are setting up the base foundation of the devices to decide what is required and what is not. We started to run testing and coding to design specifications, and ensure that we managed the configurations throughout the project. This will allow the finalization stage to be a seem-less setup with minimal bugs.
* Testing and Validation
  + Throughout this stage we will design a test plan for the system to ensure that we are meeting the required brief. We will outline user acceptance testing with stakeholders in a set meeting to ensure that we undertake the system design effectively. This will allow us to mitigate bugs in the final release.
* Documentation and User Guide
  + This stage requires the team to create a detailed guide of setting the system up to allow it work effectively. The user-guide should be easy to follow and contain media that any user can follow and be able to replicate the same results. We will conduct user testing on our documentation to ensure that it is robust.
* Demonstration and Client Review
  + Prepare a finish product and present this to the client and key stake holders to gather feedback and address any issues or concerns that may arise. Make the required changes from the provided feedback.
* Finalization and Delivery
  + We need to conduct a final review of the system and ensure that all requirements are met. Officially hand over the system to the client, provide a training session and allow ongoing maintenance and support for the project until we see it closed. Make the required documentation updates as they arise and fix any new bugs that arise.

## 

## Deliverables

We have included in our mid-year review a compilation of our installation and troubleshooting steps so far, including issues we have encountered while attempting to configure our hardware. This will prove instrumental in our final project documentation which will aim to provide a user guide of the srsRAN 4G software and its setup for compatibility with the Ettus B205 mini.

# Proposal feedback/recommendations response

In response to our mentor’s feedback, we have refined our approach to ensure it is practical, realistic and project specific. Our mentor emphasized the importance of a structured methodology tailored to our 5G indoor testbed project using O-RAN and SDRs.

1. Define Objective: Clearly listing project goals, including performance metrics and deliverable expectations.
2. Research: Conducting comprehensive research on 5G technologies, O-RAN architecture, relevant protocols, and the SDR module to build a solid foundation.
3. Preparation: Gather and familiarise our team with the required tools and technologies. This involves setting up hardware and environment, installing software, and preparing for upskilling on certain technologies our team would need to use.
4. Practical work/execution: Implement the project plan by configuring the SDR module, setting up O-RAN components, and integrating different elements to complete the 5G small cell tower, complemented by iterative testing.
5. Troubleshooting: Thorough identification, diagnosing, and resolving technical issues promptly, ensuring future project smooth implementation.
6. Documentation: Create comprehensive documentation, including user guides and technical documents, to ensure our work is reproducible, transparent, and useful for future reference or similar projects. Adopting this structure approach allows us as a group to systematically address each project aspect while remaining flexible to adapt to any challenges that emerge throughout the project.

# Variations or deviation from the proposal

* Using Mint over Ubuntu 22.04 LTS for ease of setting up
* Second networking Device added for testing.
* Change in methodology: shifting the focus away from planning system architecture and more towards the successful implementation of the technical elements

# Current project status

Our project began with receiving a previous paper that outlined the specifications for creating a 5G Indoor Testbed. We analyzed this document and identified the necessary information. Over the next few weeks, we focused on researching and upskilling in areas such as srsRAN, O-RAN architecture, and the relevant operating systems and hardware, particularly the radio module.

We have now set up the initial software configurations, including srsRAN, UHD, srsEPC, srsENB, and srsUE, and are working towards establishing connectivity between two devices for our tech demo. During this phase, we encountered an issue with the antenna fitting on the radio module, which was resolved by sourcing the correct adapters.

Despite having most of the environmental resources in place, we face challenges due to the lack of clear installation documentation, causing issues in different installation environments (WSL, virtual machines, dual-boot Linux). Each environment presents unique problems, such as port forwarding and hardware compatibility.

To overcome these challenges, we are conducting collaborative troubleshooting sessions and documenting our process with screenshots. This documentation will not only track our progress but also serve as a troubleshooting guide to help resolve future issues. Our goal is to have a working demo ready and to continue refining our setup at the start of the next semester.

## Constraints

**Hardware**

* When using the AUT desktop provided we have issues with not having full controls over it. This caused struggles with installation and even with a successful install, had issues communicating with the module.
* Have had issues with personal device being undetectable as Chris was using UTM VM to operate with ubuntu; uhd\_find\_devices and lsusb would not detect SDR module.

**Firmware/Software**

* Firmware overwriting itself in B205-mini to match firmware of srsRAN software

**Lack of Proper Installation Documentation**

* Due to a lack of proper installation documentation, we are having issues where after installing certain functions/features of the software aren’t working as they should be.
* Lack of troubleshooting guides for when installation and usability give issues.

**Simulate User Equipment**

* In an ideal scenario, we would like to connect a mobile phone to the radio module. But due to NZ mobile network security, we can’t, so the solution is to simulate/mirror this function using software.

**Deployment Scenario**

* Initially we were given one radio module, but later we found out we wouldn’t be able to simulate a connection with just one. Recently we were allocated another module and are currently working on getting communication between them.
* Choice of operating systems and virtualization options poses its own issues where each install is different and presents its own problems.

## Challenges

One of the biggest struggles we've encountered as a group has been time management, which has become progressively more challenging given the busy nature of university life. Although our team has worked hard to stay on track, balancing individual schedules with project demands has proven difficult.

Our team has faced challenges in finding a fitting and cohesive time for all members to meet regularly. University group work and varying class schedules have made it hard to coordinate our efforts effectively. Additionally, coordinating times with our mentor and moderator has been a struggle, as their availability doesn't always align with ours. This has necessitated flexibility and frequent adjustments to our meeting plans to ensure everyone can participate and contribute.

Despite these challenges, we are dedicated to keeping communication open and consistently making group compromises to make the best use of our available resources.

# Summarized individual contributions

|  |  |  |
| --- | --- | --- |
| **Contributor** | **Contribution(s): (Task/Sections)** | **Hours** |
| Edward | * Extensive research for srsRAN implementation * Primary on troubleshooting of srsRAN testbed * Primary on srsRAN documentation and guides * Contributor on proposal document (skillset and tech) * Sole production of proposal presentation and slidedeck template * Setup and organization of group OneDrive * Setup of group GitHub for phase 2 (O-RAN-Project) * Primary point of contact for mentor (meeting scheduling, USRP collection etc.) | 161 Hours |
| Sam | * Research and upskilling * Initial setup and software to be used to ettus device * Setup on campus lab computer * Contribute to Project Proposal * Contribute o Mid year review * Research for device hardware. | 74 Hours |
| Chris | * Research in project rationale * Primary initiator of project related documents * Contributor on initial srsRAN testbed setup * Contributor on troubleshooting with srsRAN setup | 121 Hours |
| Kat | * Research * Proposal documentation * Upskilling - continuous * Creation of technical documentation, troubleshooting, assistance with delegation of team tasks * Addition of deliverables and executive summary | 83 Hours |
| Will | * Research and Upskilling * Creating Risk Management Plan, Overall Risk Classification and Issue Management * Project Status and Constraints for Mid-Year Review | 51 Hours |

# Recommendations for improvements in Stage 2

* Effective time management
* Stricter deadlines
* Better resource allocation
* Feedback loop

# Schedule for Stage 2

**Winter Holiday Break**

Sprint 6: Weeks 13 – 14: Software Installation & Setup

Sprint 7: Weeks 15 – 16: First round of testing and integration

Sprint 8: Weeks 17 – 18: Network Configuration

**Mid-semester Break**

Sprint 9: Weeks 19 – 20: Functional Testing and Validation

Sprint 10: Weeks 21 – 22: Performance Evaluation, Benchmarking, and Optimisation

Sprint 11: Weeks 23 – 24: Documentation Finalisation and Client Approval