Configuration Manual

Industrial Internship
MSc Cybersecurity

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National College of Ireland

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National College of Ireland

MSc Project Submission Sheet

School of Computing

Student Name: Roopesh Srivastava

Student ID: 22164162

Programme: MSc Cybersecurity **Year:** 2023-24

Module: Industrial Internship

Lecturer: Jawad Salahuddin

Submission Due Date: 05-01-2024

Project Title: A comprehensive security approach to mitigate Replay and MITM attacks in LoRaWAN protocol.

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I hereby certify that the information contained in this (my submission) is information pertaining to research I conducted for this project. All information other than my own contribution will be fully referenced and listed in the relevant bibliography section at the rear of the project.
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Signature: Roopesh Srivastava

Date: 05-01-2024

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Configuration Manual

Roopesh Srivastava
Student ID: 22164162

1 Introduction:

This document provided a step-by-step guide to run the implementation model of the research. We have used MATLAB and GNU radio for creation of simulation of LoRa network and the flow diagram for the LoRa Transmitter and receiver respectively. The simulation involves defining the pilot signal of 868 MHz and channel bandwidth of 125 KHz. A separate model has been created to simulate the PoC of the proposed encryption scheme as per the solution of the research. The simulation utilizes different Simulink libraries, Channel blocks, Python and C programming language. The encryption scheme has been made in C and has been physically implemented in ESP32 general purpose chip. Further the GNU radio Companion software has been used to create a flow graph of LoRa transmitter and receiver to create an SDR based LoRa solution. This configuration manual gives synopsis on the guide to set up the simulation environment and execute the project successfully.

2 Simulation Set up:

Step 1: The first step is to download and install the simulation environment. We have used MATLAB version ***R2023a*** for this research. The MATLAB version can be downloaded using this link: https://matlab.mathworks.com/

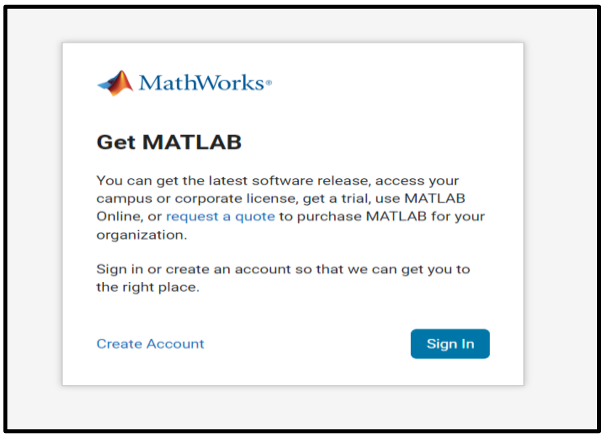


Figure 1: Sign In

Step 2: Upon finishing the account setup and sign-in procedure, we must download the MATLAB desktop client. Clicking the R2023a version button will start the download of the installer

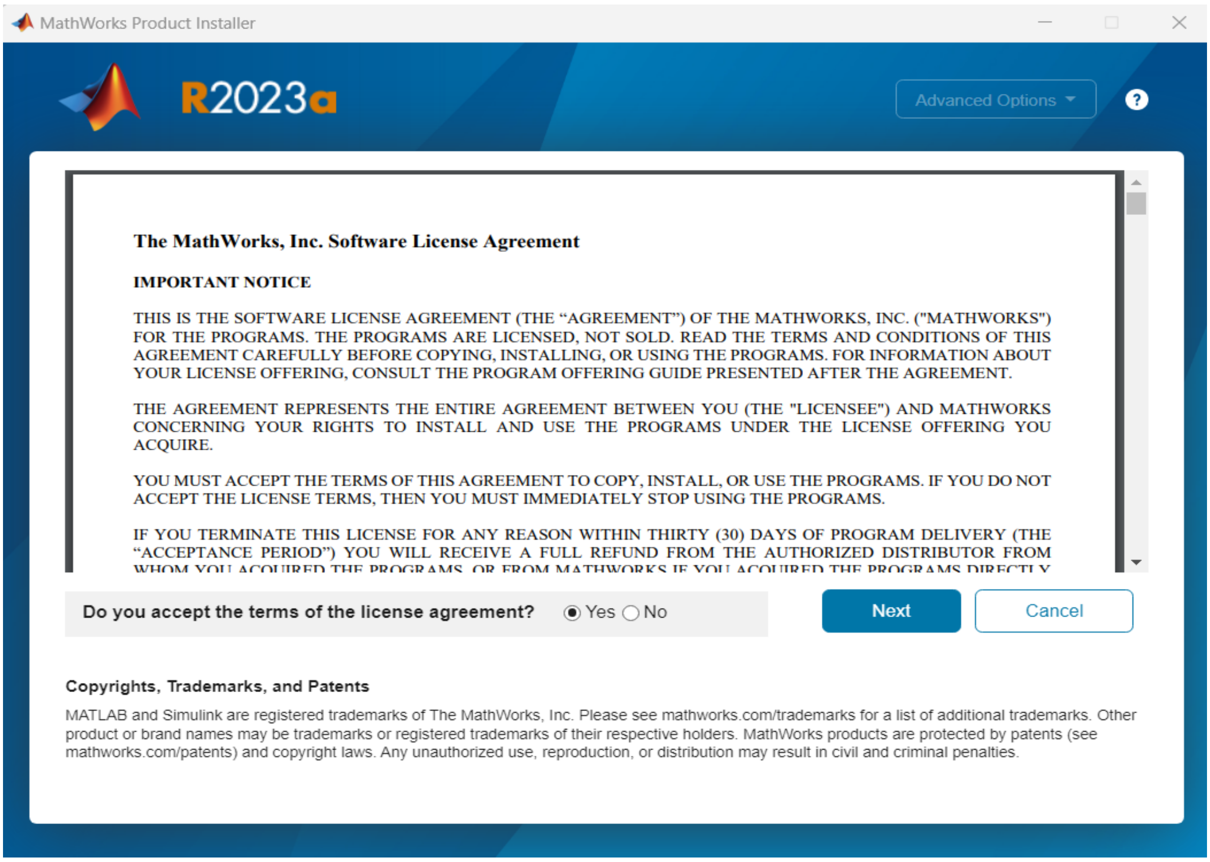


Figure 2: License Agreement

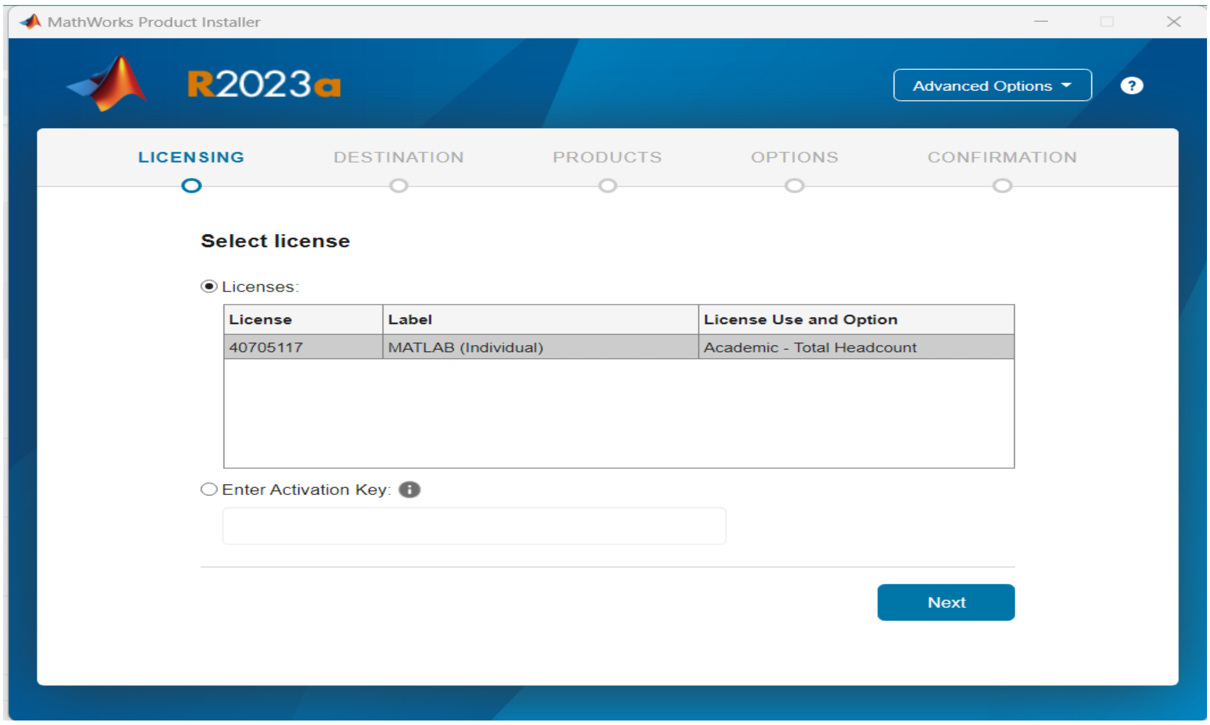


Figure 3:Activation Key

Step 3: Choose installation folder for MATLAB, we select all the default options and install all the Simulink libraries in the list. This will begin the installation.

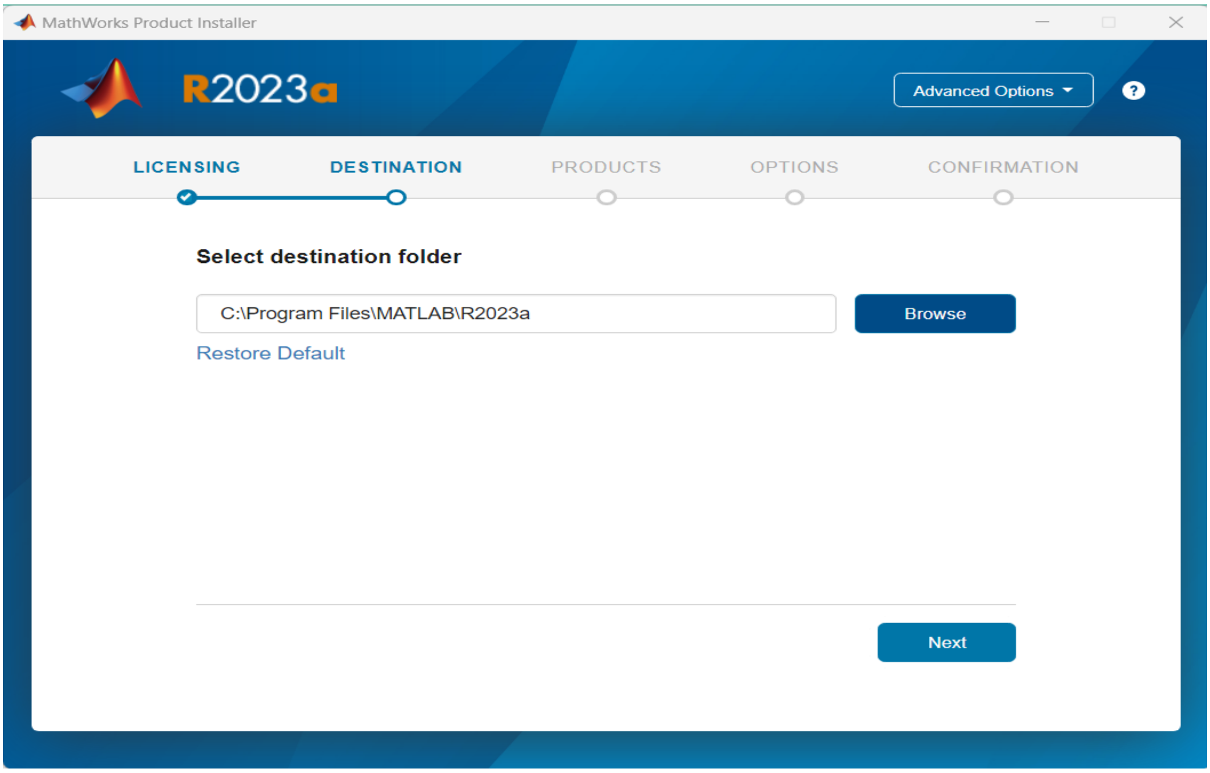


Figure 4: Installation Path

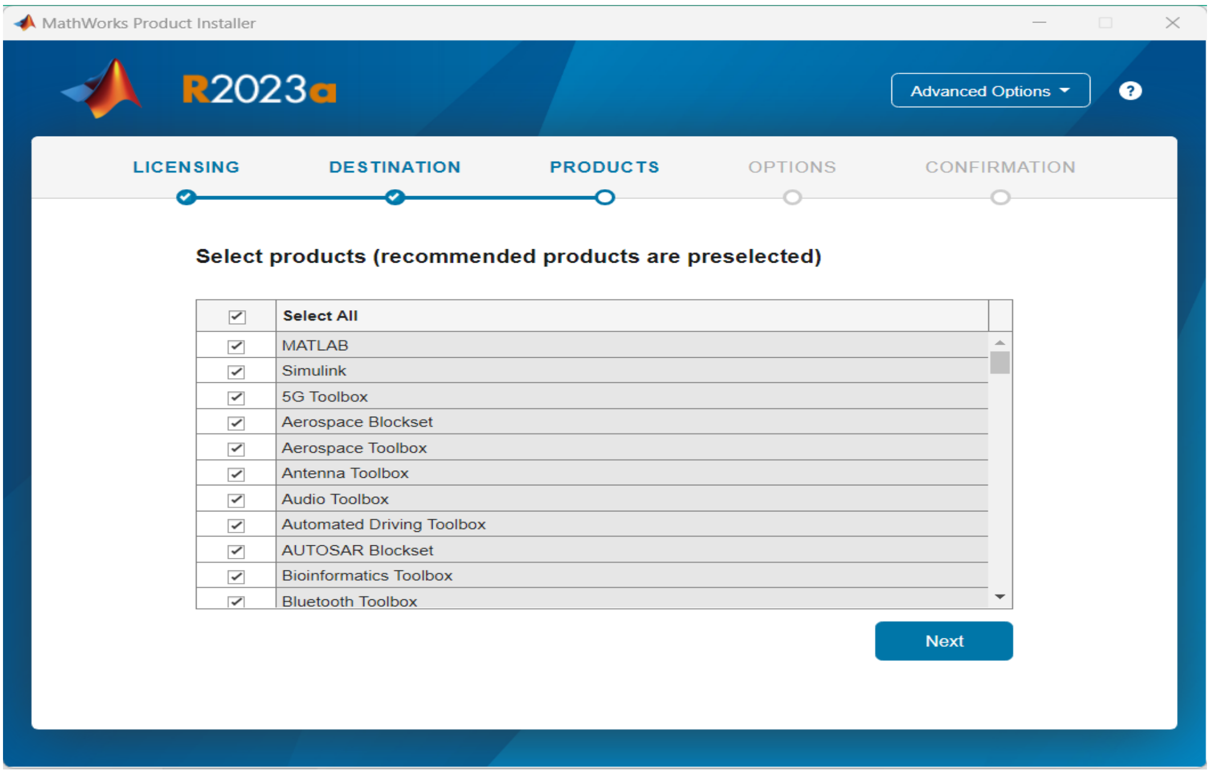


Figure 5: Products

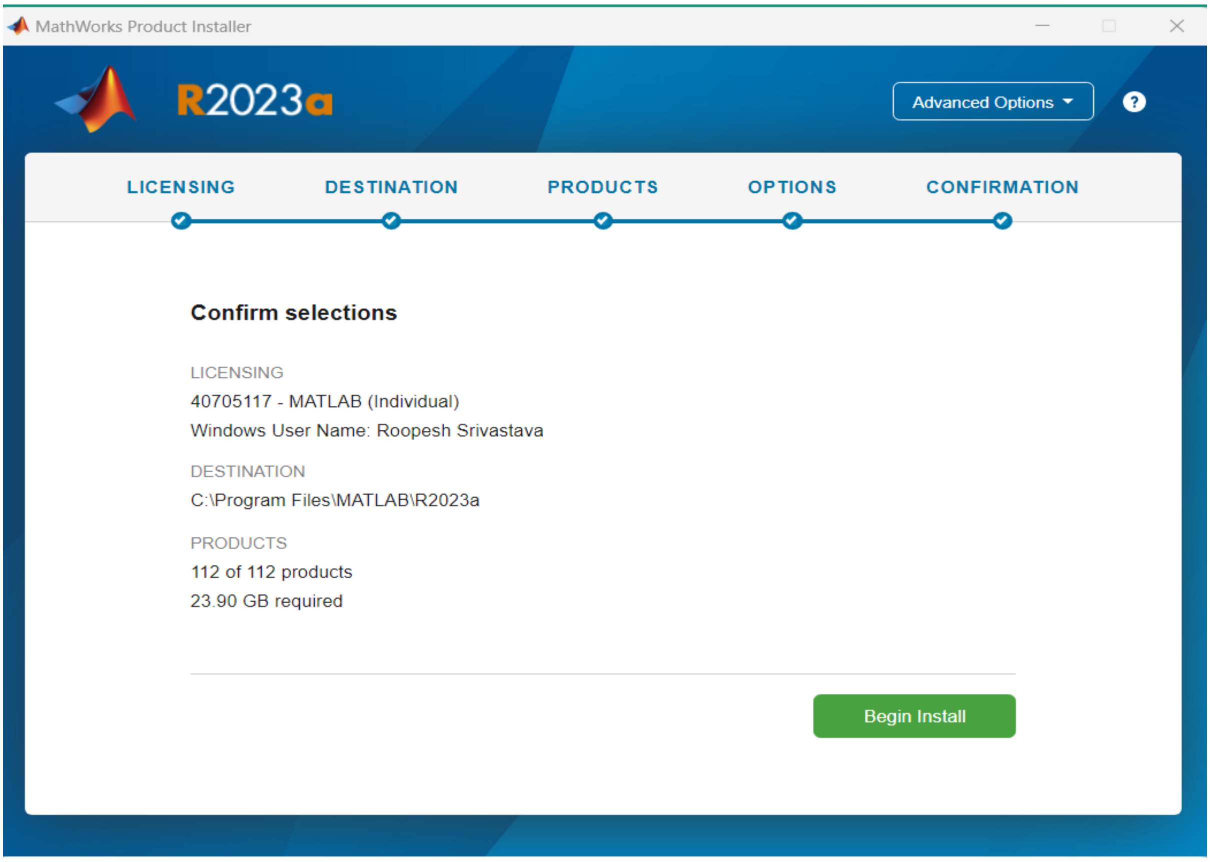


Figure 6: Confirmation

Step 4: Activate the MATLAB

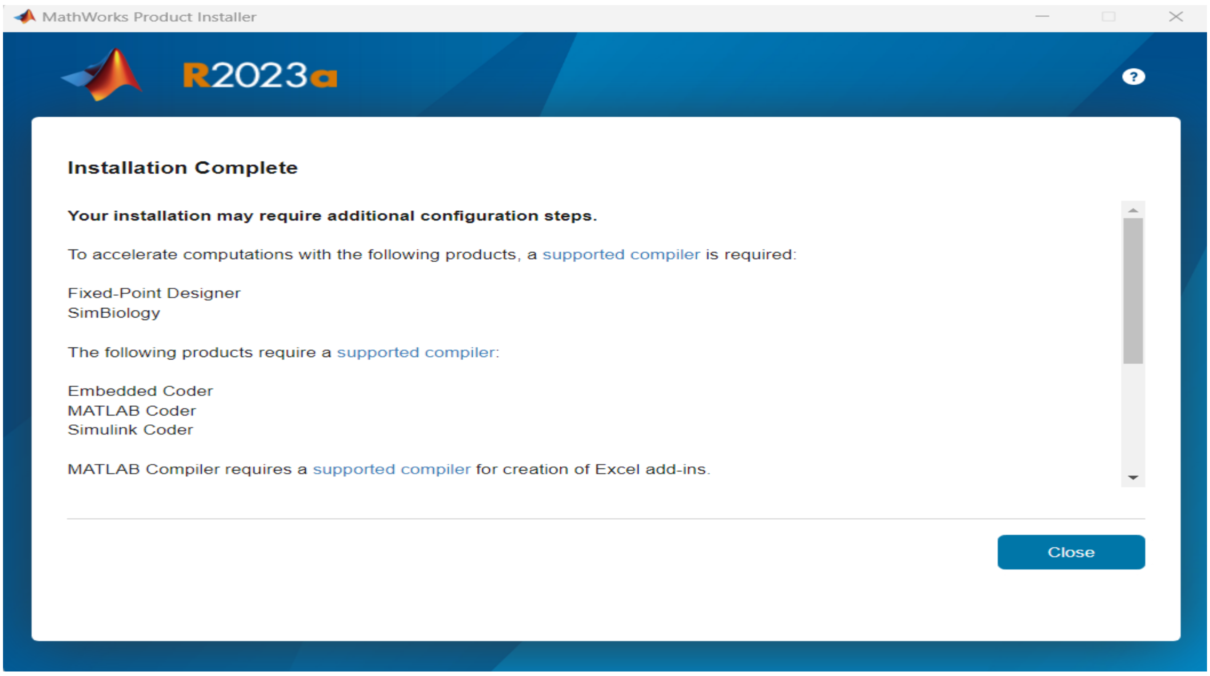


Figure 7:Installation Completion

Step 5: Open the simulation program and launch the MATLAB R2023a client.

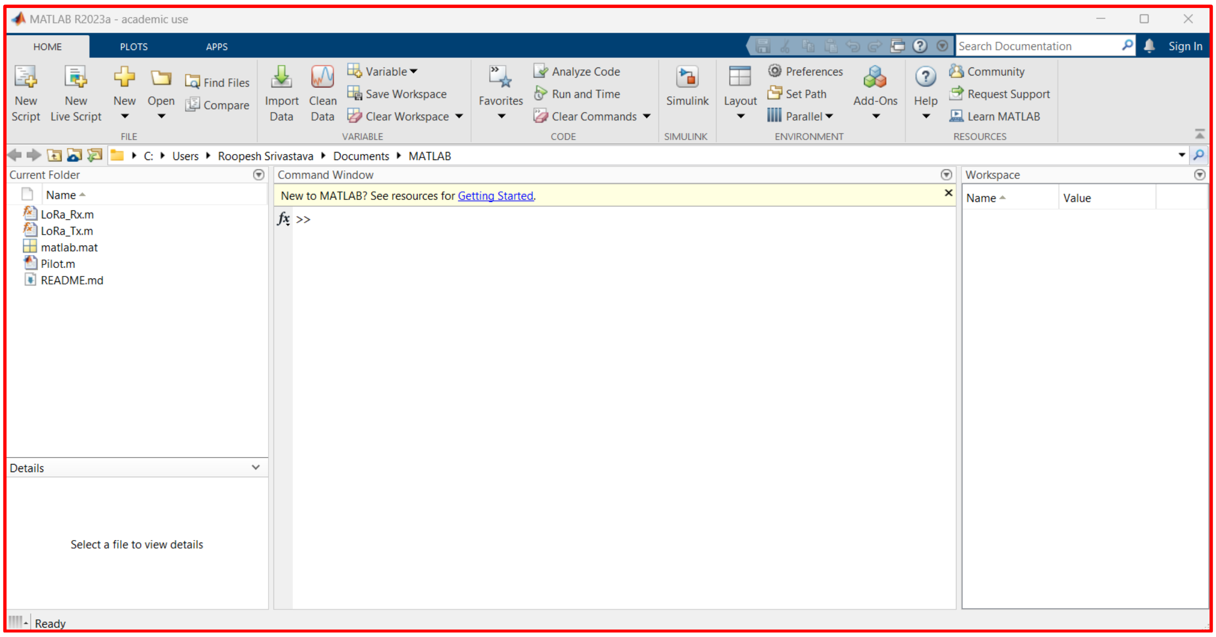
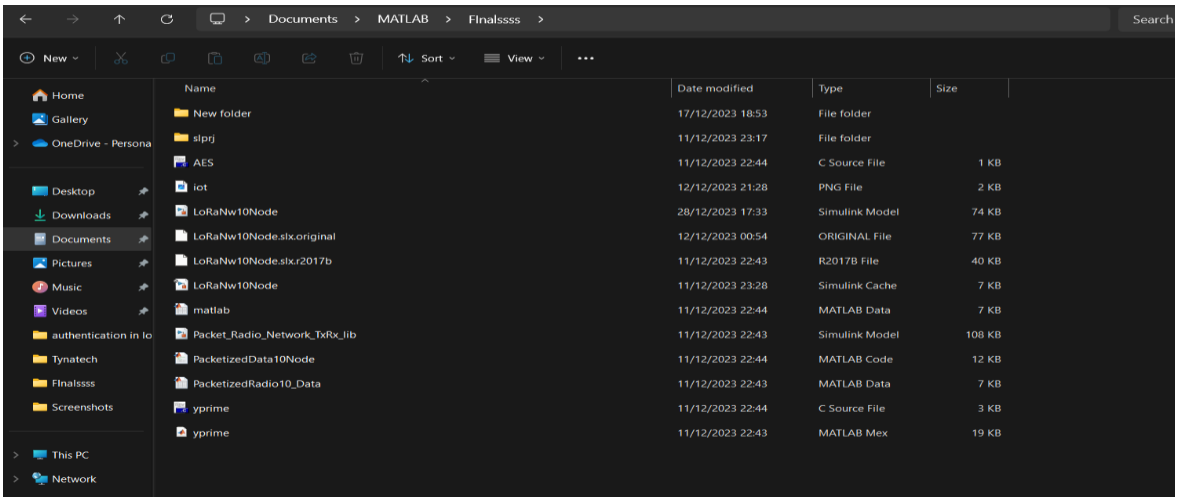


Figure 8: MATLAB GUI

3 Running the simulation:

This sets up the simulation environment, now to run the simulation, files are required to be extracted in the path and thereafter are made to run in a specific order so that the Simulink model files receives the node signals and can generate network traffic. Zip file contains multiple files. We need to run specific files for specific tasks.

Step 1: It is necessary to extract and copy the zip file to the location of the MATLAB folder. We can then add the code files to the path for execution by doing this.



Step 2: To generate the LoRa beacon signal, we need to run the *Pilot.m* file after running the *LoRa_Tx* and *LoRa_Rx* files. Here we can see the difference in the

beacon based on center frequency, bandwidth, and the spreading factor. This is essential to understand the LoRa transmission signal.

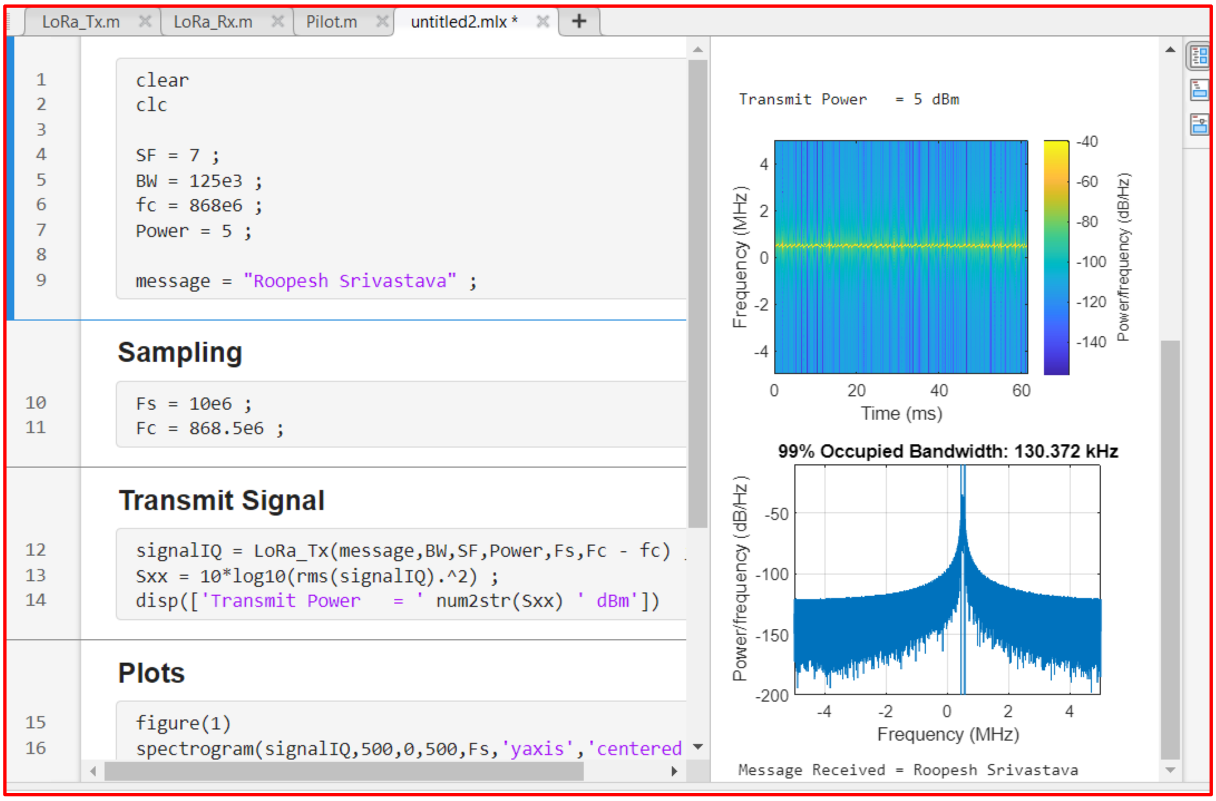


Figure 9: LoRa Pilot Simulation

In the above we have used the following

- Spreading Factor – 7
- Channel BW – 125KHz
- Centre Frequency – 868MHz
- Power – 5dBm
- Message – “Roopesh Srivastava”

The simulation creates a LoRa pilot signal with the message and sends it to the *LoRa_Tx* file. In the *LoRa_Tx* file, a payload is created using the message. Thereafter a packet is created by encoding the payload. Thereafter the chirping of the packet takes place by a spreading factor of 7. The bits are then interleaved and subsequently an IQ signal at center frequency of 868MHZ with bandwidth of 125KHz is created.

This IQ signal is then passed to the *LoRa_Rx* file along with other parameters to carryout the reverse process as the transmitter to retrieve the message.

This simulation completely describes the entire process of signal processing as per LoRa standard protocol.

Here the effect of changing the parameters on the signal can be studied.

Step 3: To simulate the data processing, a Simulink model has been created. This model carries out creation of data frame from the payload after adding the Cyclic redundancy check. The frame structure has been defined as per LoRa protocol. To run simulation, we need to run the Node frame file labelled (***Packetized3Node.m***). Upon running this file, the MATLAB generates the data frame and the ack frame. This also sends traffic to the Simulink model where it is being called. The 'Packetized3Node.m' file contains the transmitter frames and receiver ack frames for all nodes and gateway.

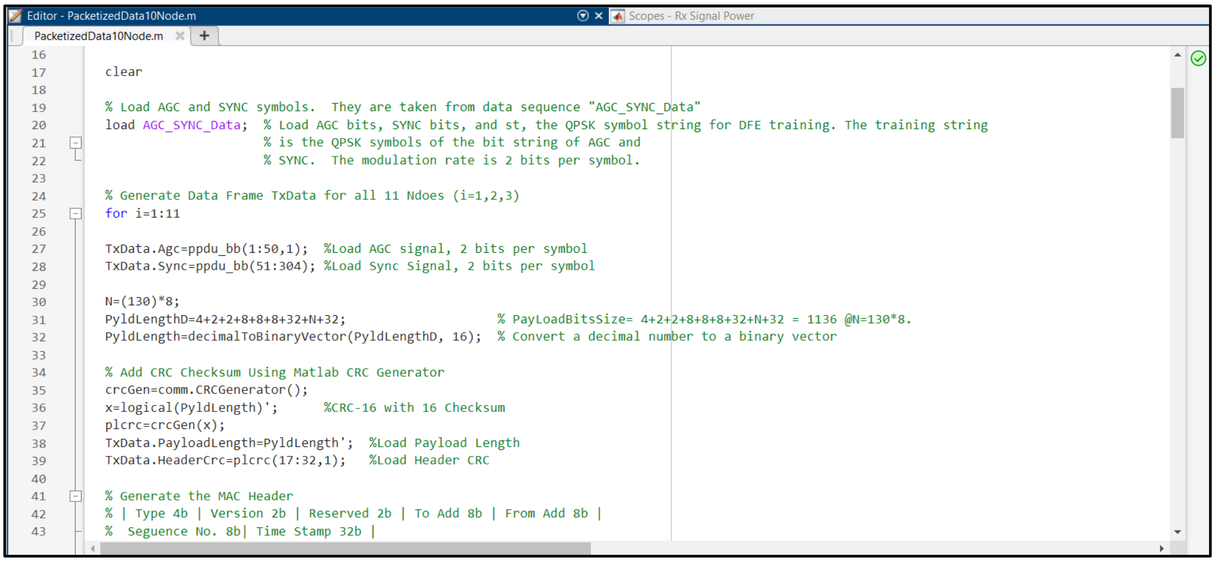


Figure 10: MATLAB File for Packet Generation

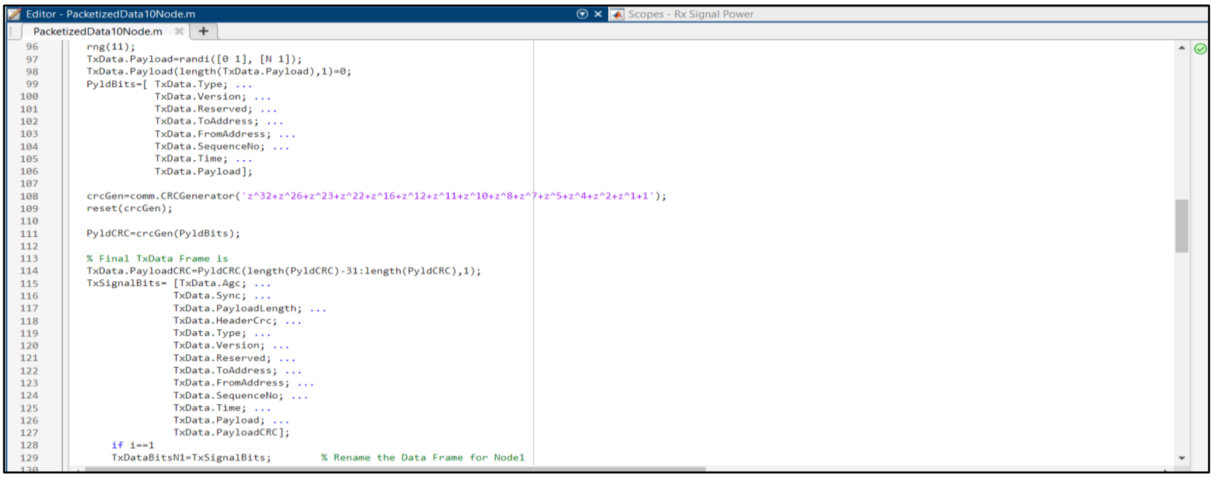


Figure 11: Tx Data Frame Structure

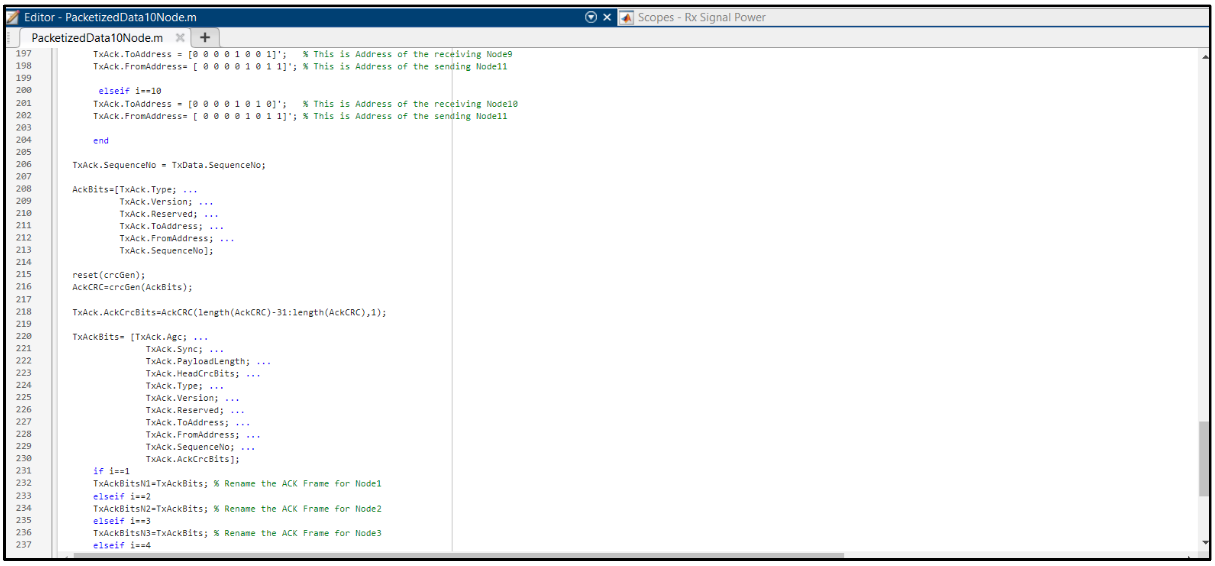


Figure 12: Ack Frame Structure

Step 4: We must now run the MALTAB data file labelled <PackatizedRadio_Data.mat> , this file defines all the variables present in the code. These can be run or either loaded from the **".mat"** file.

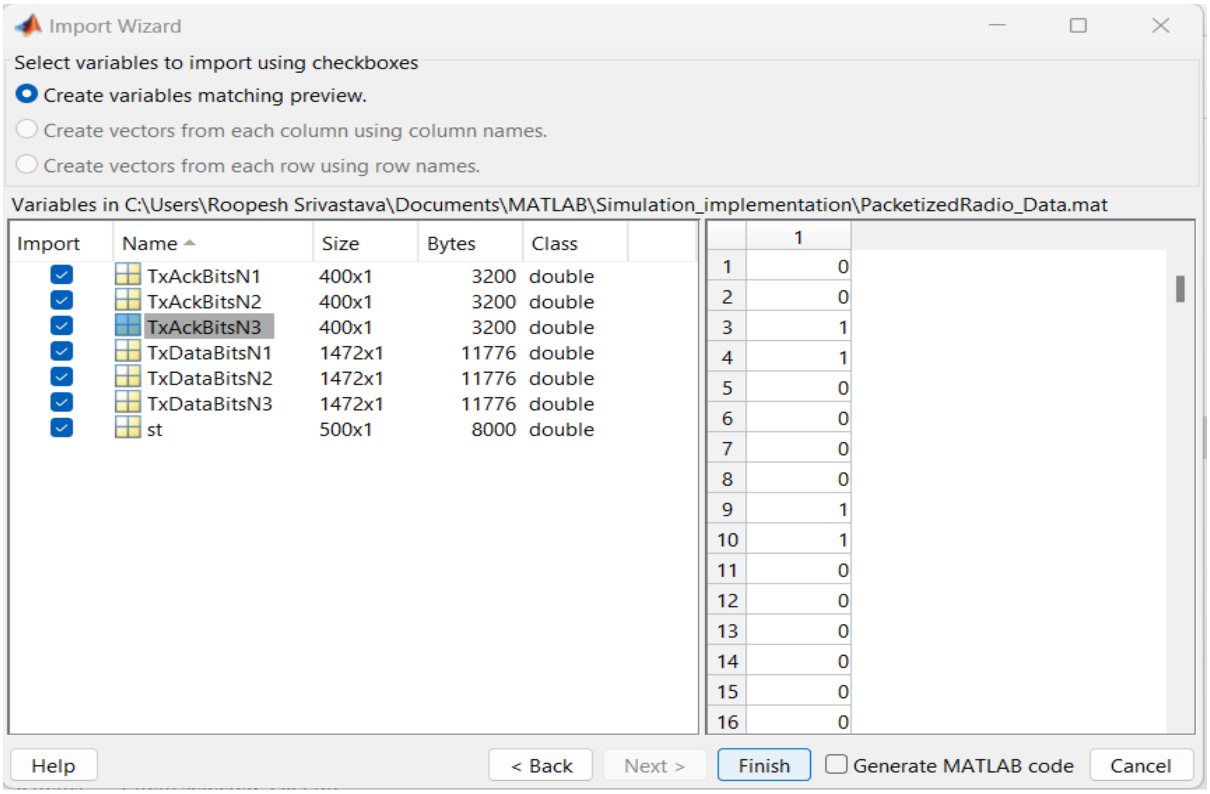


Figure 13: Simulation Variables

Step 5: Next we need to run the Simulink model file ***Lora3Node.slx***. This runs the created Simulink model in which a 10-node network is defined which is connected to the gateway.

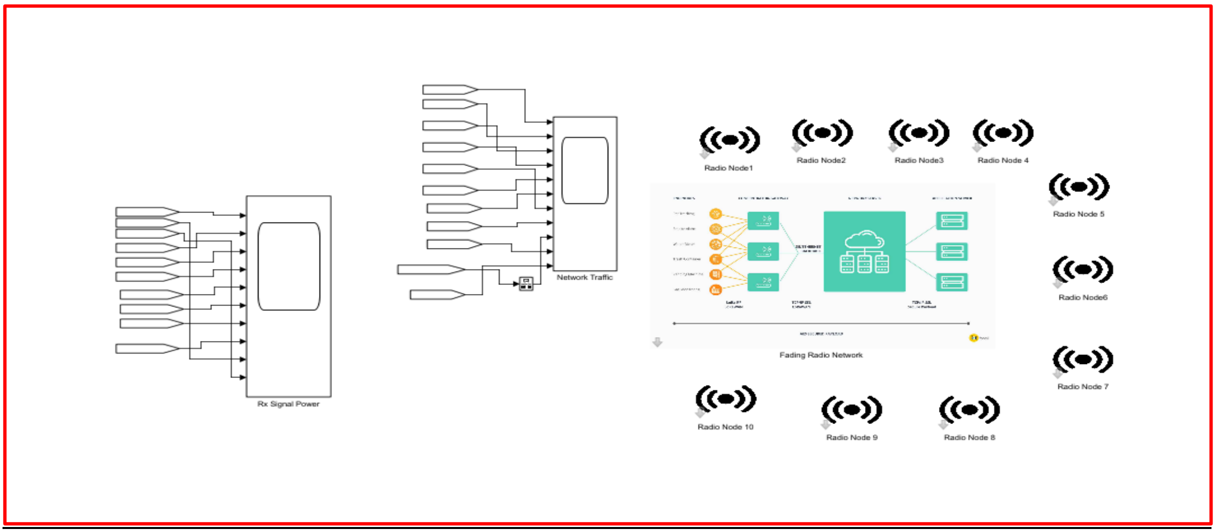


Figure 14: 10 nodes LoRa Network

Once the simulation starts, we can see the transmitted data and the received power at each node. We also see the plot for composite traffic reaching the gateway.

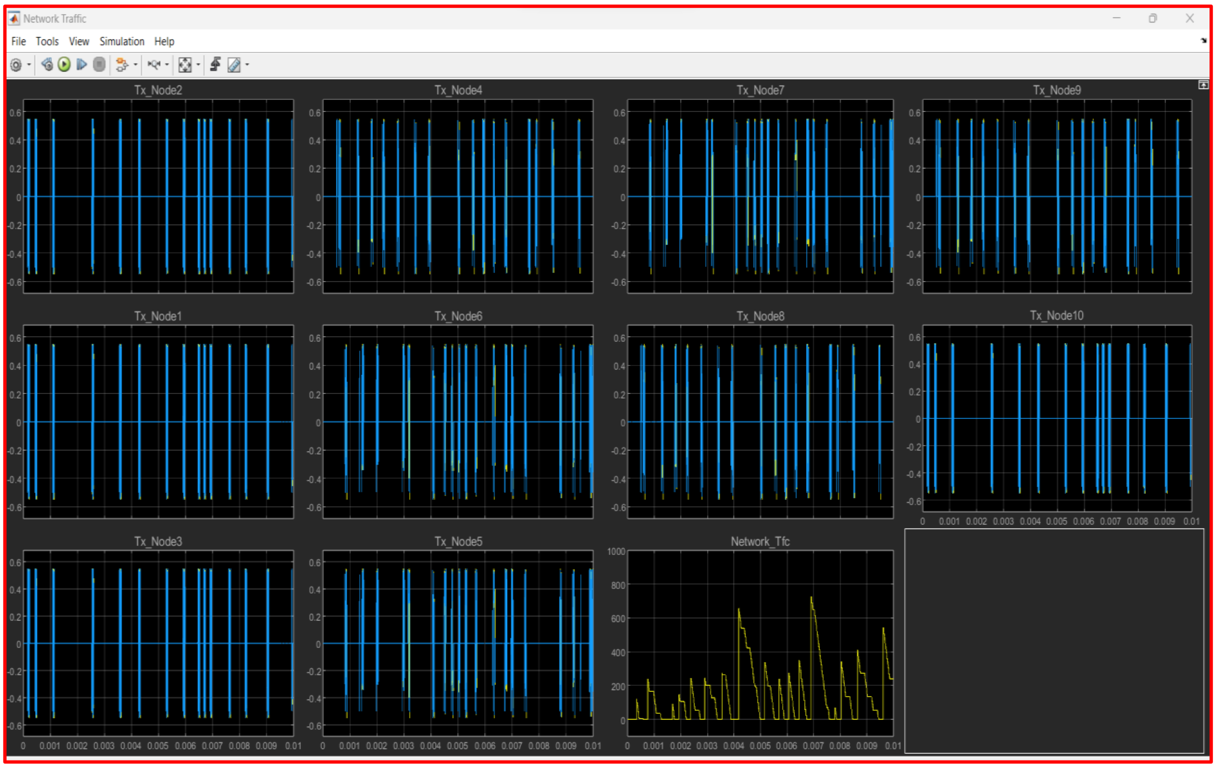


Figure 15 : Transmitted Data

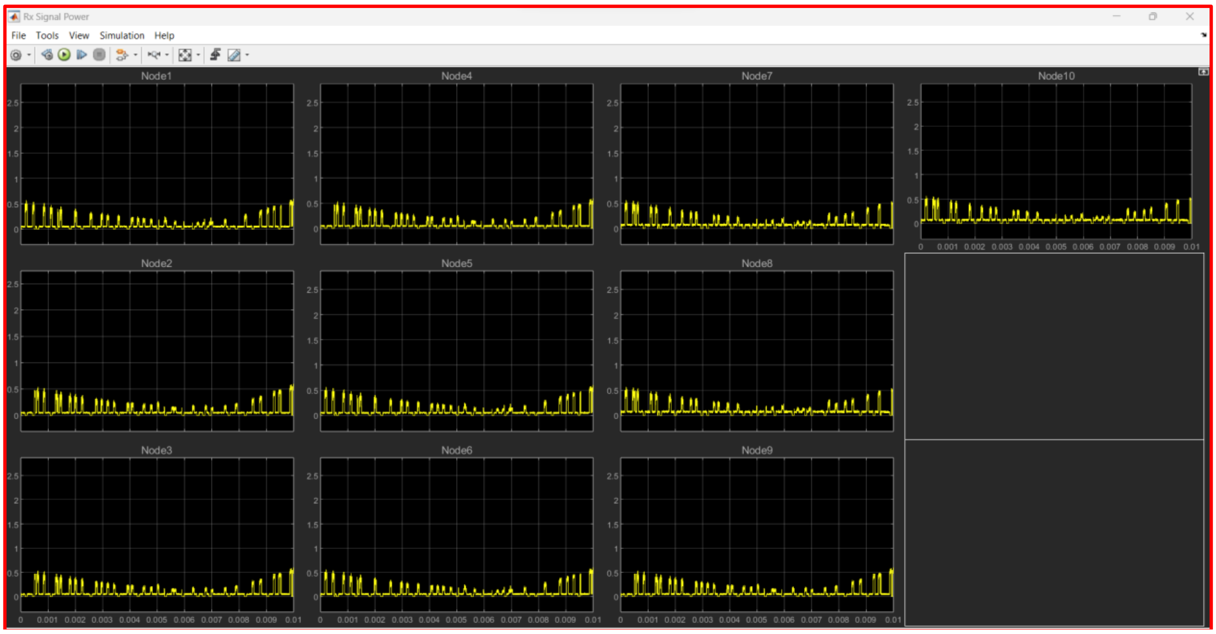


Figure 16: Rx Signal Power

Step 6: Finally, to see the proposed solution we need to run the third simulation mode with name "*Encryption prototype.slx*"

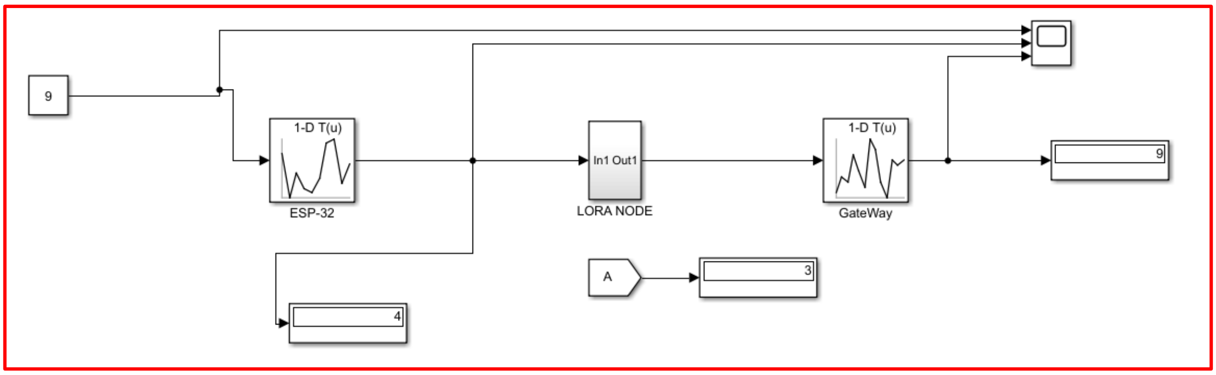


Figure 17: Encryption PoC Model

As seen from the model above an original message of "9" was encoded as "4" by the ESP 32 and passed as payload to LoRa node which again encrypted it as "3" and send it to the gateway. At the gateway end two decryption were done one after the other to finally decode the original message as "9".

4 Monthly Internship Activity Report

The internship's duration was from 25th September 2023 – 10th December 2023.

Monthly Internship Activity Report

The Internship Activity Report is a 1-page monthly summary of the activities performed by you and what you have learned during that month. The Internship Activity Report must be signed off by your Company and included in the configuration manual as part of the portfolio submission.

Student Name: **Roopesh Srivastava**

Student number: **22164162**

Company: **Tynatech Ingeneous**

Month Commencing: **October 2023**

1. Introduction to company catalog
2. Introductory interaction with Solution team for
   a. Water Management solution.
   b. Tynarace,
   c. Health Monitoring and Energy monitoring
3. Introduction to LoRaWan technology
4. Research Work
   a. Create a deck to summarise two papers on vulnerabilities in LoRaWan
   b. Create a deck on Replay attack and Man-in-the-Middle attack in LoRaWan.
   c. Tie-up with Research team to work out the way forward.
5.

Employer comments

Roopesh is diligent and hard working. He has good uptake and has displayed good understanding of the concepts. He made good efforts in day-to-day activities and in his research topic.

Student Signature:__________ Date: 01/11/2023

Industry Supervisor Signature:__________ Date: 01/11/2023

Monthly Internship Activity Report

The Internship Activity Report is a 1-page monthly summary of the activities performed by you and what you have learned during that month. The Internship Activity Report must be signed off by your Company and included in the configuration manual as part of the portfolio submission.

Student Name: **Roopesh Srivastava**

Student number: **22164162**

Company: **Tynatech Ingeneous**

Month Commencing: **November 2023**

1. Configuration of LoRaWAN Chip, Chip no. PRASGATE LORA node with LoRa Chip SX1276 & SX1278.
2. Hands-on configuration for the current solutions implemented in the company.
   a. Water Management solution.
   b. Tynarace Solutions
   c. Health Monitoring and Energy Monitoring
3. Research Work
   a. Simulation environment setup in MATLAB
   b. Create a working node-to-node connection in LoRaWAN
   c. Implement the working LoRaWAN network with at least 6 nodes
   d. Simulate proposed encryption mechanism

Employer comments

Roopesh has been involved in all the solutions in the company catalogue and has given key insights in the architectural improvements in conjunction with the solutions teams. He has been able to grasp the technical nitty gritty of LoRaWAN efficiently.

Student Signature:__________ Date: 30/11/2023

Industry Supervisor Signature:__________ Date: 30/11/2023