SOHO network using Cisco packet tracer and LoRa

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Abstract -Small Office Home Office (SOHO) network is a small LAN network. Cisco packet tracer permits us to build a network and test the communication among them. Here in our paper, we have built a network for inter-departmental communication, providing a WIFI and password. After getting confirmation on the communication between devices, we built a network using 3 LoRa - O2 devices representing 1 admin and 2 departments. Using Arduino Nano and ESP32 to establish a connection between different components, two-way communication is established (Admin to the department and inter-department). The LCD display shows us the no of packets transferred, the message sent, and the signal strength. This paper gives a rough idea of how wireless communication can take place between the devices and the departments of a small company.

***Key Words*:** SOHO, LoRa, Wireless communication, Arduino Nano, Inter-departmental communication.

1. INTRODUCTION

Cisco network simulation software – Packet Tracer which works on certain configurations such as security and routing purposes. Packet tracer helps in building network topologies, it simulates the behavior of the network and simulates routers and switches using a command line interface and it imitates modern computers [2]. Due to their software-based nature, protocols alone cannot fulfill the role of hardware routers or switches. Nevertheless, this program encompasses not just Cisco equipment but extends its support to a diverse array of network devices. So, to build a network physically, hardware devices are used. Here in this paper, we have built a network for three different departments using Cisco and LoRa.

2. PROBLEM STATEMENT

A large company having customers all over the world cannot handle the customers all alone. So, a small subbranch is built with several departments where they send and collect information between them wirelessly.

3. OBJECTIVES

These are objectives required to build our network

- Single router and single switch are to be used.
- Three departments.
- Each department is compulsory to be in different VLANs.
- Each department is essential to have a wireless network for the users.
- The network is set up for devices to get IPv4 addresses automatically.
- Interdepartmental device communication is mandatory.
- 3 LoRa devices need to be used for the communication.
- Message must pass from admin to departments.
- Inter-department communication must be done.
- Packets, message passed, and signal strength must be displayed on the LCD.

4. SOFTWARE REQUIREMENTS

4.1 Cisco packet tracer

With the use of Cisco Systems' network simulation tool, Cisco Packet Tracer, users may build virtual networks and test different network configurations in a secure, virtual setting. Students and IT professionals who wish to study and practice networking skills without having to buy pricey physical equipment will find it especially helpful. Here are a few of Cisco Packet Tracer's main attributes:

- Network Simulation: Using a drag-and-drop interface, create network topologies with a variety of Cisco devices, including switches, routers, and end devices (PCs, servers, etc.).
- Configuring Devices: Use a simulated Command Line Interface (CLI) to configure Cisco devices by simulating actual Cisco IOS commands.
- Packet Visualization: This tool allows you to view network communication by tracking and analyzing data packet flow over the network.
- Exercise and Solving issues: Utilize network design methods to solve problems.

4.2 Arduino IDE

Writing code and uploading it to Arduino boards is possible with the open-source Arduino IDE software. It offers both novice and expert programmers an easy-to-use environment in which to construct interactive electronics projects.

These are a few of the Arduino IDE's main features:

- Easy to Use Interface: The IDE has an upload button, a compilation pane, and a code editor all arranged in a clear and simple manner. Writing, compiling, and uploading code to your Arduino board is now simple thanks to this.
- Support for Multiple Boards: An extensive range of Arduino boards and comparable circuits are compatible with the Arduino IDE. From the board menu in the IDE, you can choose the particular board that you're using.

- Built-in Libraries: The Arduino IDE has a vast array of built-in libraries that offer features for communicating with different types of sensors, actuators, and displays that are frequently utilized in Arduino projects.
- Code Completion and Debugging: To help you write and debug your code, the most recent version (IDE 2.x) provides capabilities including code completion and debugging.

5. HARDWARE REQUIREMENTS

Fig- 1: LoRa

LoRa is a low-power, wide-area networking protocol that allows you to connect wirelessly to the Internet.
Specification:

- Communication distance: 5 Km
- Sensitivity: down to -148dBm
- Programmable bit rates: up to 300kbps
- RSSI dynamic range: 127dB
- Wireless frequency: 433MHz
- Working voltage: 1.8-3.7v
- Working temperature: -40 – +80

Fig- 2: Arduino Nano

Arduino Nano is an open-source microcontroller board based on the Microchip ATmega328P MCU. It provides the same connectivity and specifications as the Arduino Uno but in a more compact form factor.
Specifications

- Microcontroller: Microchip ATmega328P
- Operating voltage: 5 volts
- Input voltage: 5 to 20 volts
- Digital I/O pins: 14
- Analog input pins: 8
- DC per I/O pin: 40 mA
- DC for 3.3 V pin: 50 mA
- Flash memory: 32 KB
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock speed: 16 MHz
- Length: 45 mm
- Width: 18 mm
- Mass: 7 g
- USB: Mini-USB Type-B
- ICSP Header: Yes
- DC Power Jack: No

Fig- 3: ESP32

The ESP32 is a family of affordable and energy-efficient microcontrollers that feature integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series includes essential components like antenna switches, RF balun, power amplifiers, low-noise receiver amplifiers, filters, and power management modules. It serves as an upgrade to the earlier ESP8266 microcontroller.
Specification

- Number of cores- 2 (dual core)
- Wi-Fi- 2.4 GHz up to 150 Mb/s
- Bluetooth- BLE (Bluetooth Low Energy)
- Architecture- 32 bits
- Clock frequency- Up to 240 MHz
- RAM- 512 KB
- Pins- 30, 36, or 38 (depending on the model)
- Built-in buttons- RESET and BOOT buttons
- Built-in blue LED connected to GPIO2;
- USB to UART bridge- CP2102

Fig-4: PCF8574 module

The PCF8574 acts like an extra set of arms for your microcontroller, adding 8 multifunctional pins that can be configured as inputs or outputs to receive or send signals. It communicates through the I2C bus and can power LEDs directly, making it a handy tool for expanding your project's capabilities.
Specification

- VCC and GND- Power and ground, respectively
- AD0-AD2- Address pins, tied directly to PWR or GND.
- SDA and SCL- I2C inputs
- INT- Active low open-drain interrupt pin (output): this can be connected to the interrupt input on an MCU.

Fig-5: 4*4 Keypad

The 4x4 matrix keypad is commonly used as an input device in various projects. It features 16 keys, offering 16 distinct input values. This non-encoded keypad consists of 16 parallel keys, with rows controlled by pins, labeled R1-R4 and columns controlled by pins labeled L1-L4. Each row and column are connected through external pins, forming an intersection grid.

Pin designations are marked on the PCB, with four pins serving as the 'x' coordinates and the other four as the 'y' coordinates. Additionally, the module comes with pre-soldered pin headers for straightforward integration into projects
Specification:

- Key layout: 4 rows x 4 columns (16 keys total)
- Key Type: Membrane.
- Operating voltage: 3V - 5V DC.
- Interface: 16 digital pins
- Connector: Female 2.54mm Pitch.

Fig-6: Buzzer

A buzzer is an audio signaling device that can be mechanical or electromechanical. Common applications for buzzers include alarm systems, timers, and devices providing confirming user inputs like mouse clicks or keystrokes.
Specification:

- Rated Voltage: 6V DC
- Operating Voltage: 4-8V DC
- Rated current: <30mA
- Sound Type: Continuous Beep
- Resonant Frequency: ~2300

Fig-7: LCD Display

It features a display with 16 columns and 2 rows, allowing for a total of 32 characters. Each character can be a letter, number, or even a custom symbol, making it versatile for various applications.
Specification:

- Operating Voltage: 4.7V to 5.3V
- Operating Current 1mA (without backlight).
- Can display (16x2) 32 Alphanumeric Characters.
- Custom Characters Support.
- Works in both 8-bit and 4-bit Mode.

Fig- 8: Power supply

specification

- Input Voltage: 5-12V DC
- Output Voltages +5V, +12V, +1.8V, +3.3V
- Inputs DC Socket and output connected to Burg Connectors
- Maximum Load: 0.5 Amps

6. BLOCK DIAGRAM

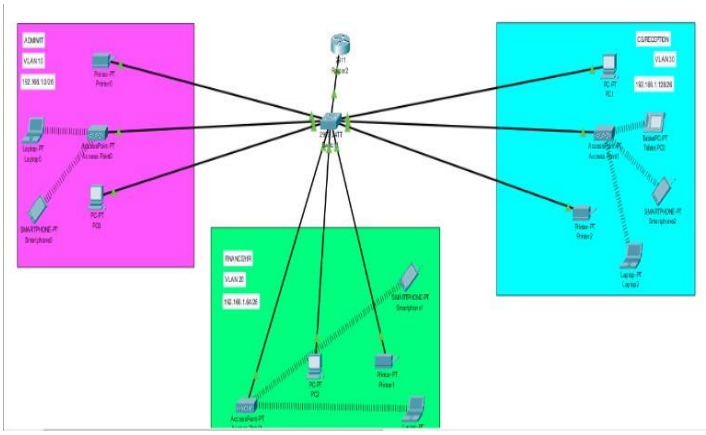

Fig – 9: Network using cisco

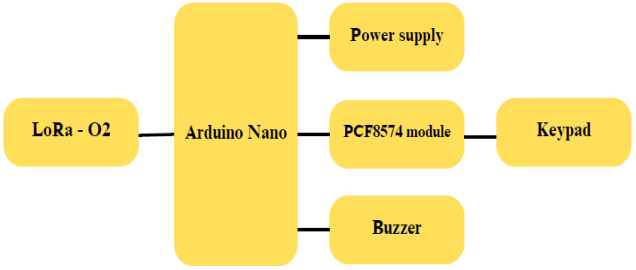

Fig- 10: Transmitter (Admin)

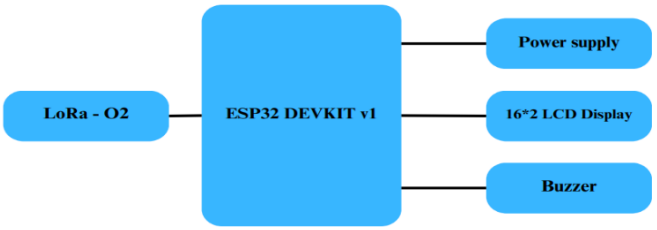

Fig- 11: Receiver 1 (department 1)

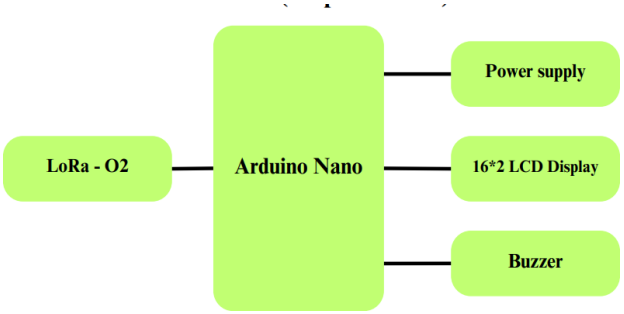

Fig- 12: Receiver 2 (department 2)

Fig- 10 shows the block diagram of the transmitter (admin) where all the components are connected according to it. Similarly, Fig- 11 and 12 shows the receiver 1 and 2.

7. METHODOLOGY

7.1 Cisco packet tracer

Using the Cisco packet tracer, the three departments were created as shown in Fig- 9. Here the communication established can be only verified on the Cisco packet tracer. Let us assume the admin needs to communicate with one of the end devices or the end device needs to communicate with the admin. The device should have the ID and the password of the admin. Once the device connects itself to the admin with the ID and password, then they can communicate with each other. The dotted lines in the Fig- 9 refer to the establishment of the connection.

7.2 LoRa device

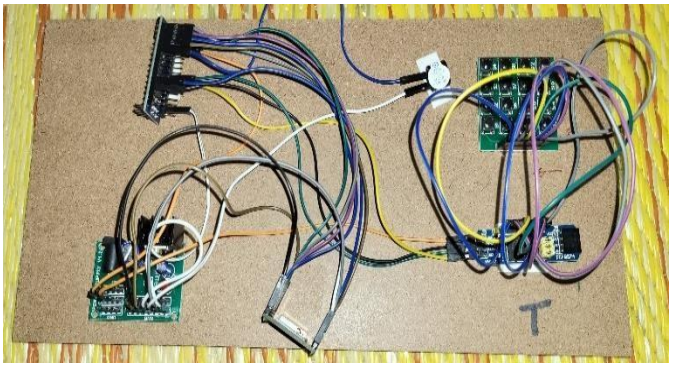

Fig- 13: Transmitter (admin) circuit connection

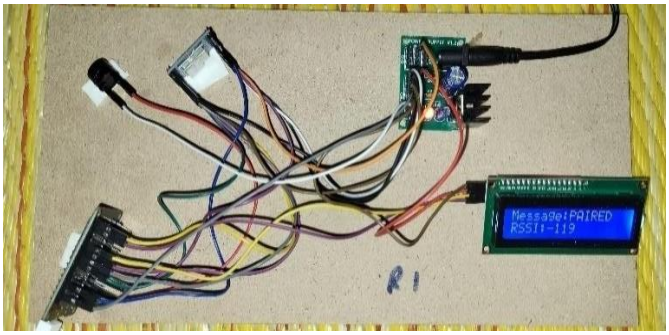

Fig- 14: Receiver 1 (department 1) circuit connection

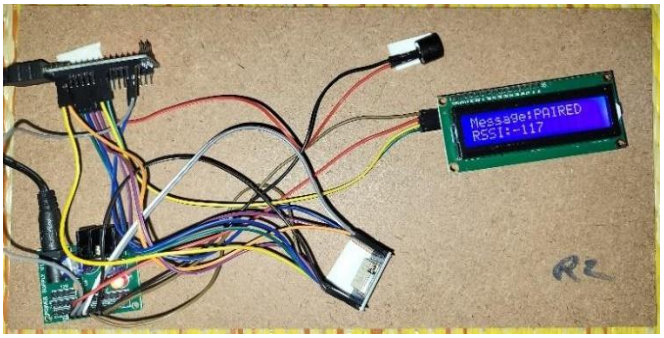

Fig- 15: Receiver 2 (department 2) circuit connection

As mentioned in Sec- 6.1, the Cisco packet tracer cannot show the packets and messages sent. Here by using a LoRa device, we can overcome that disadvantage. The transmitter is shown in Fig- 13 and receivers are in Fig- 14 and Fig- 15. The connection is established between the transmitter and 2 receivers.

8. RESULT

8.1 Cisco packet tracer simulation

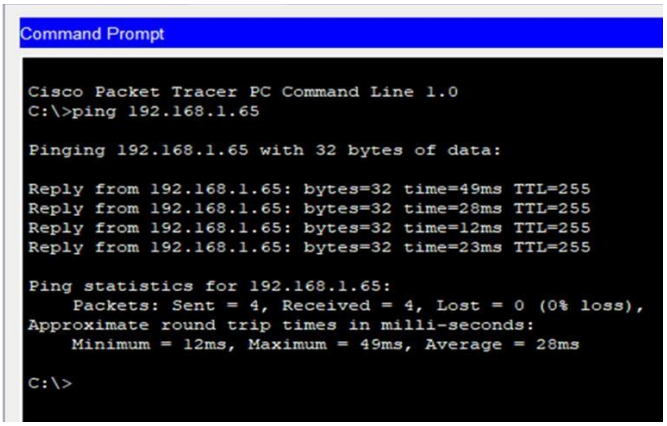

Fig – 16: Ping from one device with the IP address.

The aim of this project is to simulate SOHO networks. This project involves usage of a Cisco packet tracer for the simulation and implementation. We have used three subsystems, 1 router, and 1 switch for the network. Changing the configuration and adding the password to the system to connect one another. At the end "PING" the message to confirm the link and the message can be sent between devices.

8.2 LoRa

Once the connection is done, the Buzzer should sound if all the connections are correct. Then the message "paired" is displayed on the LCD display as shown in Fig- 16. Once the devices are paired, now messages can be passed. Case 1 is where we can send the message from the admin to the departments. Here as shown in Fig-18, the message is passed to department 1 as "Printer ON" when pressed 1 in the keypad and the department 2 as "1". Similarly, in case 2 the message is passed to department 1 as "Printer OFF" and to department 2 as "2" when pressed 2 as shown in the Fig- 19. Now in case 3 when pressed 3 department 2 displays as "IoT HUB ON" and in department 1 as "3" as shown in Fig- 20. In case 4 when

pressed 4 department 2 displays as “IoT HUB OFF” and in department 1 as “4” as shown in Fig- 21.

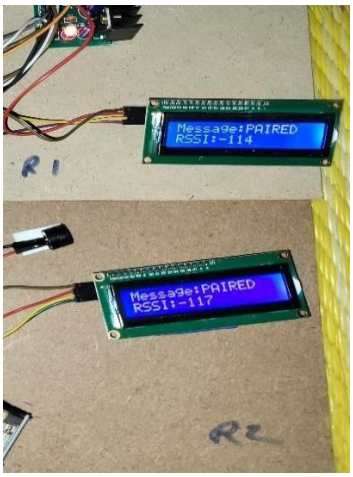

Fig – 17: Device paired

Case 5 is the inter-departmental communication between departments 1 and 2. Here the message sent from department 1 to department 2 as “HI” and it is displayed in the department 2 LCD display as shown in Fig- 22. The last, case 6 is from department 2 to department 2 to 1. Here the display of department 1 is displayed as “HELLO” as shown in Fig- 23.

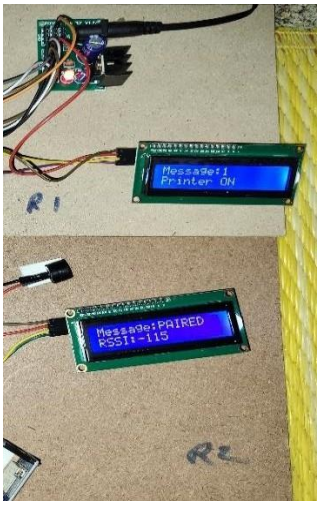

Fig- 18: Case 1

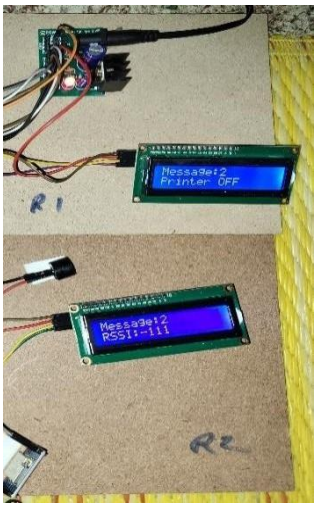

Fig- 19: Case 2

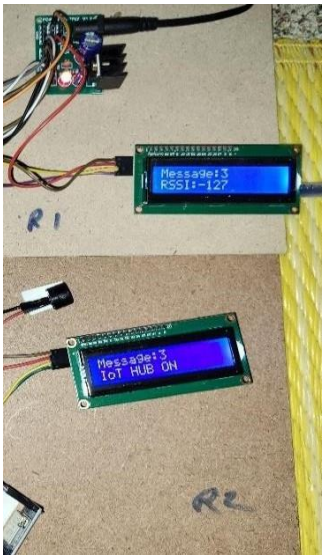

Fig- 20: Case 3

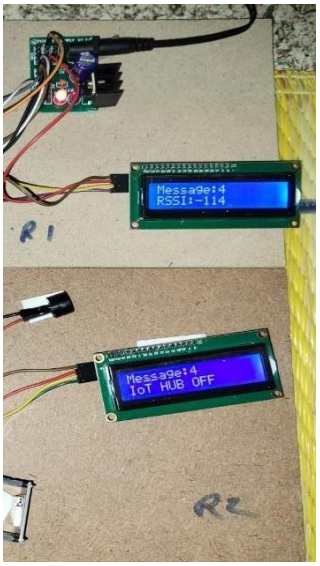

Fig- 21: Case 4

Fig- 22: Case 5

Fig- 23: Case 6

Fig- 24: Case 5 serial window

Fig- 25: Case 6 serial window

Fig- 24 & Fig- 25 shows the serial window of departments 1 & 2 when the messages are sent between them.

Table -1 shows the detailed view of all cases 1 to 6.

The cases are verified and the message can be passed. The RSSI in the Fig represents the signal strength. Here the signal strength is not constant since it depends on the environment around the LoRa and the distance between the departments.

Communication	Transmitter (Admin)	Receiver 1 (Department 1)	Receiver 2 (Department 2)
Case 1-from admin to departments	Press 1 in the keypad	Message passed as “Printer ON”	Message passed as “1”
Case 2-from admin to departments	Press 2 in the keypad	Message passed as “Printer OFF”	Message passed as “2”
Case 3-from admin to departments	Press 3 in the keypad	Message passed as “3”	Message passed as “IoT HUB ON”
Case 4-from admin to departments	Press 4 in the keypad	Message passed as “4”	Message passed as “IoT HUB OFF”
Case 5 -from department 1 to department 2	————	Message passed to department 2 as “HI”	Message received as “HI”
Case 6 -from department 2 to department 1	————	Message received as “HELLO”	Message passed to department 1 as “HELLO”

Table -1: Detailed view of cases

9. CONCLUSIONS

In this paper, we have tried to implement a Small Office Home Office network using a Cisco packet tracer and LoRa device for wireless communication between three departments (admin, departments 1 & 2) for several cases. LoRa device is used to communicate and display the packets, signal strength, and message passed. In the future wireless communication as a major impact so on a large scale, this can be implemented for communication by taking a LoRa device as an antenna. Also, the range differs when used on a large scale based on the distance of the antenna.

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We agree to allow the viewers to download the paper.

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