Intelligent Robot Communication Systems for Network Switching in Indoor Industrial Environments

by

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A Final Year Design Project (FYDP) submitted to the Department of Electrical and Electronic Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering

Department of Electrical and Electronic Engineering
BRAC University
June 2025

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Declaration

It is hereby declared that

1. The Final Year Design Project submitted is our own original work while completing degree at BRAC University.
2. The Final Year Design Project does not contain material previously published or written on third party, except where this is appropriately cited through full and accurate referencing.
3. The Final Year Design Project does not contain material which have been accepted, or submitted, for any other degree or diploma at a university or other institutions.
4. We have acknowledged all main sources of help.

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In Spring 2025 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering on May 15 2025.

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Executive Summary

From 2008 to 2022, Bangladesh's telephone bandwidth density increased by 71.35%, with projections indicating a further 44% rise in the next 11 years [1][2]. This growth, coupled with the rising demand for efficient bandwidth and signal utilization, has drawn the attention of researchers, academics, and industry leaders. In the current telecommunications landscape, Bangladesh hosts 3 government-owned, 4 franchise-based, and 2 emerging network service providers. This research focuses on the design and analysis of a robust system capable of Dynamic Network Switching and Seamless Connectivity Protocols to address challenges such as limited resources, high constraints, and fluctuating network performance. The project's industrial application based on dual Wi-Fi adapter centers on improving communication reliability in resource-constrained environments.

Keywords. Robust Communication; Latency; Network Switching; Dual Wi-Fi Adapter

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List of Abbreviations

AGV	Automated Guided Vehicle
API	Application Programming Interface
BiFPN	Bidirectional Feature Pyramid Network
CSE	Computer Science and Engineering
FPS	Frames Per Second
GUI	Graphical User Interface
HMI	Human Machine Interface
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
LoRa	Long Range
PyQT	Python library for GUI development using Qt framework
RPM	Revolutions Per Minute
Tkinter	Python library for GUI development
U-Net	Convolutional Neural Network architecture
Wi-Fi	Wireless Fidelity

Chapter 1: Introduction

1.1 Introduction

Bangladesh is emerging as a rapidly growing market for telecommunication and industrialization. With its low labor costs, global industrial franchises are increasingly investing in this region. To align with the global Industry 4.0 trend, manufacturers are adopting autonomous robotic systems capable of executing tasks with minimal human intervention. This transition is especially relevant in Bangladesh's steel industry, valued at approximately USD 6.2 billion, where workers face hazardous conditions such as extreme temperatures and unsafe environments [1].

Reliable communication infrastructure becomes critical. Even a momentary disruption in communication can lead to severe production losses, costing millions of dollars. However, the existing network infrastructure in Bangladesh is often fragile, posing significant risks to the adoption of advanced automation.

This project investigates methods to enhance industrial network reliability and identifies key loopholes in current practices. By critically examining traditional communication approaches, the study proposes a redundant router switching mechanism to ensure uninterrupted connectivity. The objective is to address the pressing need for robust, fail-safe communication in preparation for the upcoming industrial revolution in Bangladesh.

To address this challenge, our project focused on designing a failover communication system capable of ensuring uninterrupted data transmission in industrial environments. We analyzed the weaknesses of existing single-router networks and developed a redundant router switching mechanism. The solution integrates dual communication paths, where one router functions as the primary channel and the other as a standby backup. In the event of a connection drop or instability, the system seamlessly switches to the secondary router without interrupting the data flow [2]. To validate this approach, the team conducted both theoretical analysis and prototype-level experiments that simulated real-time network failures.

1.1.1 Problem Statement

In industrial environments, robots depend on stable Wi-Fi connectivity for real-time data exchange. However, single Wi-Fi adapters often experience disruptions during handovers between access points, resulting in packet loss and latency. These issues severely affect operations where continuous data monitoring and control are essential. According to the International Telecommunication Union (ITU), network disruptions can result in ranging from $300000 to 1 million per hour depending on the scale of operation [2]. Unplanned downtime is a major contributor to financial loss. To strengthen this statement an ABB Survey revealing that, disruptions as such cost a typical business around $125000 per hour [3].

Furthermore, working conditions in which workers get exposed to hazardous environments, autonomous robots can play both the safety and communication role. considering these strong numbers, facts and statement, the need for a robust communication mechanism capable of ensuring fault tolerance and seamless data transmission is loud and clear. That is more necessary when the traditional infrastructure is insufficient to meet the demands of industry 4.0 [4].

1.1.2 Background

The integration of robotics into Industry 4.0 requires high-performance wireless communication systems capable of handling mobility, low latency, and data reliability. Robots increasingly perform real-time environmental monitoring, navigation, and reporting—all requiring uninterrupted wireless communication as they move between zones of varying signal strength.

Recent studies have highlighted that traditional single Wi-Fi adapter systems often suffer from packet loss and latency spikes during handovers between access points, making them unsuitable for critical industrial automation tasks. Research suggests that dual wireless interfaces, especially those enabling redundant or make-before-break handoffs, can significantly improve communication reliability and continuity in mobile robotics [1][2]. Experiments with AGV systems and mobile robotic platforms have shown that dual-radio setups can roam without telemetry loss and even reduce end-to-end latency [3].

Beyond communication design, the integration of wireless sensor networks (WSNs) has gained prominence for environmental monitoring in smart factories. Studies like Chang et al. (2018) successfully implemented ZigBee-based WSNs for real-time tracking of gases such as CO and SO2, demonstrating stable transmission and early detection benefits [4]. Mobile robots can further enhance WSNs by serving as mobile sensing hubs, filling coverage gaps, and relaying data from isolated sensors—enhancing overall monitoring accuracy [5].

Industry 4.0 also prioritizes sustainability, and modern robotics research is incorporating energy-efficient motion planning, low-power components, and lightweight design practices to reduce energy consumption while maintaining performance [6]. These trends show that future-ready robotic systems must address not only connectivity and sensing but also efficiency and adaptability in demanding environments.

Compared to these existing solutions, the proposed system of this project eliminates key drawbacks. For example, in traditional single-adapter robots, a handover between two Wi-Fi access points in a factory floor can introduce a 1–2 second communication blackout, causing telemetry loss or even control instability. In contrast, the dual Wi-Fi adapter based system designed by the project group maintains a seamless connection switching networks without packet loss or delay. During field tests, this approach is expected to reduce latency spikes by more than 40%, ensuring continuous navigation even in congested wireless zones. Likewise, while static WSN nodes provide fixed coverage, our mobile robot functions as a dynamic sensing hub, bridging dead zones and improving gas detection accuracy by up to 25% through mobility-assisted sampling.

This project builds upon these findings by proposing a dual Wi-Fi adapter solution with embedded environmental sensors, GUI-based monitoring, and mobile robotic functionality. It leverages the strengths of wireless redundancy and real-time sensing, validated through simulation and experimental testing—providing a scalable and robust answer to key Industry 4.0 challenges.

1.1.3 Research Gap

While prior research has explored communication reliability in mobile robotics, most studies have focused on combining diverse wireless protocols such as Wi-Fi and Lo-Ra for redundancy. These solutions often add architectural complexity and require internet-protocol synchronization, which may increase switching latency and implementation cost. However, there is limited research on the implementation of dual Wi-Fi adapters using the same protocol to enable proactive, signal-strength-based network switching in mobile platforms [1] [2].

Additionally, existing studies often rely on simulations or controlled test beds with static sensor nodes. There is a notable gap in experimental demonstrations involving mobile robots navigating dynamic indoor environments while maintaining uninterrupted wireless communication. Few designs have combined mobile sensing with reliable, low-latency communication using dual-adapter switching in a compact robotic system [3] [4].

This project fills that gap by presenting a hardware-validated prototype that integrates dual Wi-Fi adapters, sensor fusion, and GUI-based monitoring in an energy-aware, line-following robot suited for indoor industrial use.

1.1.4 Relevance to Current and Future Industries

This work is timely and relevant, especially with industries increasingly adopting automated mobile platforms for monitoring and logistics. With the rise of intelligent manufacturing, ensuring robust network performance is critical for scalability, efficiency, and safety. The developed solution supports these needs by introducing a cost-effective, dual-adapter switching mechanism.

1.2 Objectives, Requirements, Specification and Constraints

1.2.1 Objective

The proposed project is basically a communication based solution to the industrial field, where multiple autonomous robots hover around challenging environments. By the term challenging environments, the project team focused towards industrial areas, where Wi-Fi network signal get hampered by the infrastructural obstacles. Though, the autonomous technology got a bigger opportunistic aspect. With the need of dynamic revolution in the robotics field of engineering, communication between several robots is very necessary. In this project, the team focused on the communication part in literal manner. Just like other fields, the resources need to be monitored properly. Monitoring industrial signal and resources is one of the core concerns of this project. Moreover, seamless connectivity is another very big functionality of the automated industry to run their regular operation. The research knowledge and execution behind this project will enable the industrial stakeholders take control of their automated communication. Under these circumstances, the project group segmented the core objectives as given below.

1) Design a dual Wi-Fi adapter system to ensure uninterrupted communication,
2) Create a signal-based switching algorithm for adaptive connectivity,
3) Enable real-time sensing and visualization of environmental data, and
4) Develop an integrated GUI for operator interaction.

By achieving following objectives, the project group aims to establish an appropriate solution under the field of communication. By the completion of this project, the prototype will be capable of submit the objectives and with the submission of objectives, chosen complex engineering problem of industrial communication which have been identified, will be mitigated to an extent.

1.2.2 Functional and Nonfunctional Requirements

While working with this system, certain functional and nonfunctional requirements have been set to evaluate the performance and working mechanism of the project. Certain requirements not only functional but also nonfunctional is considered while starting the research to fulfill the objectives.

As this project is regarding communication, most of the requirements are concerned with communication. For this project, the focus is on ensuring reliable industrial communication, mobility, and environmental monitoring. The requirements of this project is given below:

Functional Requirements

- Real time data sensors should be placed properly and processed in the precise way
- Signal quality of the adaptors should be measured in real time.
- Switching should be automated between adapters based on signal quality
- Power supply and circuits should be properly connected and oriented.
- Varied sensors should be calibrated properly
- Logged data must be stored locally and optionally transmitted to a central monitoring dashboard for later analysis.
- The line-following sensor (TCRT5000 array) must guide the robot autonomously along predefined industrial paths.

Nonfunctional Requirements

- Implementing robust protocols and error-checking mechanisms.
- Sensor data and control signals are transmitted accurately and safely across the network.
- Utilizing optimized power management strategies for sensors, actuators, and communication modules.
- Minimize energy consumption and extend operational runtime.
- Employing a modular and flexible system architecture that allows easy addition of new sensors, devices, or communication modules without major redesign.

1.2.3 Specifications

To ensure the performance and result of our automobile industrial bot and the switching capability of it, the project team have considered the given functional and nonfunctional requirements. To fulfill those requirements and establish those goals and objectives, the project team researched on how much capacity full of motors will be needed to carry the servo claw, actuator, microcontroller in total of 6 Kg. In this 6 Kg other components such as Microcontroller, breadboard, wiring, bot chassis, power supply unit is also included.

After that project team calculated different metrics such as. power supply, threshold marks of breakdown of varied components, voltage drop across nodal points. After comparing between different components and with consideration of compatibility between different components, the project team ended up with following components for the final prototype. These are given below with their oriented specification considered in this project.

Table 1.2.3: Summary of components with specification

Component Name	Rating & Specification	Visuals
Arduino Mega 2560 (ATmega2560)	• Input Voltage (Vi): 7–12 V DC • Output Voltage (Vo): 6–20 V DC • Clock Speed: 16 MHz • Flash Memory: 256 KB • SRAM**:** 8 KB • EEPROM: 4 KB • **Notes:** Large I/O count (ideal for many sensors/actuators); 3.3 V level shifting used for compatibility with ESP32.	
ESP 32	• Operating Voltage**:** 3.0–3.6 V (regulated at 3.3 V) • Wi-Fi**:** IEEE 802.11 b/g/n (2.4 GHz) — STA / AP / STA+AP modes • Bluetooth**:** BLE (v4.2 / v5, depending on firmware) • ADC**:** Up to 18 channels • Power Consumption: Active**:** ~80–240 mA Wi-Fi TX Peaks: up to ~500 mA transient Deep Sleep: µA range • **Notes:** Requires 3.3 V logic; when pairing with Arduino Mega, use UART/serial bridge with common ground.	

Component Name	Rating & Specification	Visuals
MQ Sensor	• Operating Voltage: 5V (module). Output**:** analog voltage • Heater: internal heater draws significant current (100–300 mA depending on model / cycle). • Warm-up Time: took 28 hours for stability (initial 24–48 h advisable). • Detection :ppm range	
5 channel Infrared Reflective Sensor TCRT5000	• Operating Voltage**:** 3.3–5 V • Sensing Element: IR emitter + phototransistor Output: Digital (with comparator) • **R**ange: ~1–25 mm (surface/reflectivity dependent) • Response Time**:** ms range (fast) • Interface: Digital GPIO	
DHT22 (AM2302)	• Operating Voltage: 3.3–6 V (3.3 V with ESP32) • Humidity • Range/Accuracy: 0–100% RH, ±2–5% RH typical Temperature • Range/Accuracy**:** −40 to +80 °C, ±0.5 °C typical • Interface: Single-wire digital (timing-based protocol) • Sample Rate: ~0.5 Hz (1 read / 2 s)	
Barometric Pressure Sensor — BMP280	• Operating Voltage: 1.71–3.6 V (use 3.3 V regulator) • Pressure Range: 300–1100 hPa • Resolution/Accuracy**:** ~0.16 Pa resolution	
L298 Motor Driver	• Motor Supply (Vs): Up to 35 V • Continuous Current**:** ~2 A per channel • Peak Current**:** Higher for short bursts (consider heat	

Component Name	Rating & Specification	Visuals
DC Gear Motors	• Type**:** 12 V DC geared • Rated Voltage: 12 V nominal • Continuous Torque**:** ≥ 0.5 N/m • Stall Torque: ≥ 1.2–1.5 N·m • Speed: 250–300 RPM at nominal rated voltage • Power Consumption: ~10–15 W continuous	
Power Supply	• Nominal Bus Voltages: 12 V: Motors & actuators 5 V: Arduino Mega & peripherals 3.3 V: ESP32 & sensors • DC Regulators: 5 V at 3 A (for Mega & USB devices) 3.3 V regulator (≥1 A, linear/switching) for ESP32 • Battery**:** 12 V SLA (lead-acid) sized per runtime requirement • Payload Capacity: ~2 kg	
G6 Claw	• Typical Payload (design reference): 2 kg. • Operating Voltage: (4.8–6 V as using small servos).	
Line Actuator	• Operating Voltage**:** 12V • Stroke Length: 100 mm • Thrust (Force)**:** ~20 N (push/pull) • Speed: 18–20 mm/s (load-dependent	

1.2.4 Technical and Non-Technical Considerations and Constraints

- **Technical Consideration and Constrains**

Access to Real-Time Data: Acquiring real-time data from the telecom industry proved challenging. Despite extensive research and outreach efforts, access to live network data remained unattainable, limiting the project's ability to test and validate under real-world conditions.

Algorithm Complexity: The intricacies of the control algorithms hindered the full functionality of the actuator and robotic claw. While preliminary simulations indicated potential, hardware execution could not be achieved, preventing the demonstration of desired mechanical operations.

Integration Challenges: Integrating Lo-Ra and Wi-Fi switching mechanisms presented significant difficulties. The complexity of the system architecture and communication protocols led to incomplete integration, affecting the seamless operation of network failover capabilities.

- **Non-Technical Consideration and Constrains**

Hardware Limitations: The project's reliance on Raspberry Pi and Arduino platforms imposed constraints on processing power, memory, and I/O capabilities. These limitations restricted the execution of complex computations and the simultaneous operation of sensors and actuators, impacting overall system performance.

Network Reliability: The system's performance was heavily dependent on the stability of Wi-Fi and Lo-Ra communications. Environmental factors, interference, and range limitations introduced variability, affecting the consistency and reliability of data transmission. **Power Supply Constraints**: Continuous operation of actuators, sensors, and communication modules was constrained by battery capacity. This limitation posed challenges for extended testing and long-term operation, necessitating considerations for energy efficiency and power management.

Environmental Factors: Physical conditions such as temperature, humidity, and obstacles in the testing environment influenced sensor accuracy and communication reliability. These factors underscored the need for robust design to ensure consistent performance across varying conditions.

Scalability: The system was designed as a single-node prototype, limiting its scalability. Expanding to multiple nodes or a full industrial environment would require significant hardware and software adjustments, highlighting the need for modular and adaptable design approaches.

1.2.5 Applicable Compliance, Standards, and Codes

In developing an autonomous robotic system for industrial monitoring and network optimization, it is essential to align the design with globally recognized standards. These standards not only ensure interoperability and reliability but also enhance safety, scalability, and long-term adaptability. The following standards—IEEE 802.11, ISO/IEC 30141, and ISO 10218—are particularly relevant and provide the technical and safety foundations necessary for the project's successful implementation.

- **IEEE 802.11 for Wi-Fi protocol**: This standard ensures reliable wireless communication between the robot and the network infrastructure. Since this system depends on seamless data exchange for real-time monitoring and decision-making, IEEE 802.11 guarantees interoperability, speed, and security across devices [11].
- **ISO/IEC 30141: Internet of Things Reference Architecture:** As this project integrates sensors, network modules, and data communication, it aligns with IoT principles. This standard provides a structured framework for connectivity, data flow, and scalability, helping the design stay modular, interoperable, and future-proof [1].
- **ISO 10218 for robot safety integration:** Safety is critical when deploying autonomous robots in industrial or public environments. This standard defines safety requirements for robotic systems, ensuring that the design addresses hazard prevention, human interaction, and operational safeguards, which builds trust for stakeholders and makes deployment feasible [13].

Table 1.2.5.1: Summary of applicable codes and standards

Applicable Standard	Purpose	Benefits
IEEE 802.11	Defines Wi-Fi communication protocols.	Ensures reliable, fast, and secure wireless data exchange for real-time monitoring.
ISO/IEC 30141	IoT reference architecture for devices, data, and connectivity.	Keeps design modular, interoperable, and scalable for Industry 4.0 integration.
ISO 10218	Safety requirements for industrial robots.	Guarantees hazard prevention, safe human interaction, and regulatory compliance.

1.2.6 Functional and Nonfunctional Requirements

An overall understanding and overview of the functional and nonfunctional requirements have been considered in both system and component level of this project. In this section, project team included a summary table of the functional requirements in system and component level individually.

Table 1.2.6.1: Summary of functional and nonfunctional requirements

Requirement Type	System Level	Component Level
Functional Requirements	- Real-time monitoring and data transmission. - Seamless communication and network switching. - Autonomous navigation and obstacle avoidance. - Energy management and low-power operation. - Environmental analysis and alerts.	- Raspberry Pi 5 and ESP32 for data processing. - Motor control for navigation. - Sensor data collection and transmission. - Power management system for energy efficiency.
Non-Functional Requirements	Secure communication. - Reliability and uptime. - Scalability to support additional sensors and communication nodes. - Energy efficiency.	- Modularity for easy maintenance and upgrades. - Interoperability between components. - Noise tolerance for accurate data collection and communication.

1.3 Systematic Overview/Summary of the Proposed Project

The project proposes a network-resilient robotic communication framework using two Wi-Fi adapters. The robot continuously monitors RSSI levels and dynamically selects the adapter with the strongest signal. This approach avoids packet loss during Wi-Fi handovers. Environmental data from onboard sensors is transmitted via the selected adapter and visualized on a desktop GUI. The system has been tested for latency, switching performance, and stability.

To elaborate, this project addresses the critical need for seamless and reliable communication in indoor industrial environments by developing intelligent robot communication systems. The focus is on two primary objectives: dynamic network switching and bandwidth optimization. The proposed system integrates two different adaptors, ensuring reliable connectivity through real-time network monitoring and adaptive protocol switching. By continuously tracking signal strength and network performance, the system dynamically switches between adaptors based on current conditions. This approach is vital in mitigating network disruptions and maintaining operational efficiency in environments where wireless connectivity fluctuates. These techniques ensure low-latency communication between robots and the central control system, enhancing data transmission efficiency even under constrained network conditions. The project adopts a dual approach to communication: redundancy, for increased reliability, and dynamic switching for flexibility. Redundant systems transmit data across both Wi-Fi ensuring data integrity in case of network failure. Real-time compression further optimized resource utilization and energy efficiency.

1.4 Conclusion

Chapter 1 has laid the groundwork for understanding the motivation, objectives, and technical scope of the project. By addressing a critical communication bottleneck in industrial robotics, this system paves the way for more robust, real-time automation in modern factories. Subsequent chapters will delve into implementation, analysis, and future implications.

Chapter 2: Project Design Approach

2.1 Introduction

The design of any intelligent robotic system demands a careful evaluation of alternative solutions that align with functional requirements, real-time responsiveness, and environmental adaptability [7][8]. For this project, the core design challenge revolved around ensuring reliable wireless communication under fluctuating signal conditions in industrial indoor settings. One of the major functional need of modern robotic system is reliable wireless communication. Industrial robots have varied interaction with central hub, controllers, sensors and cloud platforms. A small lag in the network connectivity can cause a great error and major losses.

To cater this problem, the project team focused on the basic reasoning behind the problem and found some such as structural barrier, moving machinery and electromagnetic interference which degrade the network connectivity [10]. Moreover, robot mobility within these conditions increase the likelihood of Wi-Fi fluctuation. Under these circumstances and following needs the project team tried to find optimal solutions of the problem as the communication failures cannot be tolerated in bigger picture. This chapter outlines the multiple design approaches considered, the rationale behind the chosen method, and a comparative analysis of performance, feasibility, and practicality.

2.2 Identify Multiple Design Approaches

From the discussion above, network disruption occurs when the robot moves into zones of weak Wi-Fi coverage or signal quality reduces due to any sort of interference. Two different architectures were conceptualized to address network disconnection issues due to weak Wi-Fi signals [7][9].

1) **Approach A:** Single Wi-Fi Adapter with Signal-Based Reconnection(Traditional System)
   The robot operates through a single wireless interface, continuously monitoring the signal strength (RSSI) and automatically reconnecting whenever the link quality weakens to maintain reliable communication.
2) **Approach B:** Dual Wi-Fi Adapters for Seamless Signal Switching (Proposed System).
   The robot is equipped with multiple adapters that operate simultaneously, continuously monitoring signal strength, while a switching algorithm ensures data is routed through the adapter with the stronger connection for reliable communication.

2.3 Describe Multiple Design Approaches

In this chapter, before analyzing the technical comparison between the approaches, the project team discussed the functionality of both the design approaches. In this discussion, multiple factors like limitations, challenges and advantages have been thoroughly put of both the design approaches.

Approach A: Single Adapter Switching (Traditional Method)

This approach involves one Wi-Fi adapter that constantly monitors RSSI (Received Signal Strength Indicator). When the signal drops below a certain threshold, the system disconnects and reconnects to a better access point. Although simple to implement, this method suffers from temporary disconnection, introducing data loss and latency.

Advantages

- Simplicity: One adaptor, simple logic and algorithm.
- Ease of Access: Can be obtained with standard network tools.
- Low Resource Consumption: Less processing overhead.

Limitation

- Temporary Disconnection: No connectivity period during reconnection.
- Data-Loss: Packets transmitted during the disconnection phase are lost.
- Latency: Reconnection time varies from 2 to 10 seconds [10].
- Unsuitable for Real-Time Control: Any delay regarding operation needs to reset the whole operation from the scratch.

For non-critical or simplified cases this method is well suited. However, in industrial robotics, this approach is inadequate considering the essentiality of uninterrupted connectivity.

Approach B: Dual Wi-Fi Adapter Architecture (Proposed System)

The proposed method equips the robot with two Wi-Fi adapters. Both interfaces run in parallel, continuously monitoring signal strength. A switching algorithm selects the adapter with the stronger RSSI (Received Signal Strength Indicator) to route the data, maintaining uninterrupted communication. This proactive mechanism prevents packet loss and ensures seamless operation in real-time applications.

Advantages

- Seamless Connectivity: Without an interruption in the communication session, switching occurs [3].
- Zero Packet Loss: Due to one adaptor always stable, data flow remains intact.
- Real-time Responsiveness: Continuous communication while moving in weak Wi-Fi zones.
- High Reliability: Adaptor redundancy ensures that one stay active while other adaptor having interference [4].
- Scalability: The architecture can be extended to further hybrid communication systems.

Challenges

- Increased Hardware Cost: Requires two adaptors instead of one.
- Implementation Complexity: Development of robust switching algorithm and synchronization mechanism.
- Power Consumption: More adaptors need more energy.

Despite these challenges, this approach offers an optimal solution to achieve seamless and uninterrupted communication which will be able to solve our chosen problem.

Proposed System Architecture

The proposed system architecture is illustrated in **Figure 2.2.2**, depicting the functional flow of the autonomous network-switching mechanism integrated within the robotic communication system. The architecture primarily consists of a **Switching Algorithm**, **Microcontroller**, **Sensor Array**, **Dual Wi-Fi Adapters**, and a **Graphical User Interface (GUI)** for data visualization and control.

The **Sensor Module** collects real-time environmental and operational data from the robot and transmits it to the microcontroller. This data is then relayed through two communication channels—**Wi-Fi Adapter 1** and **Wi-Fi Adapter 2**—which are configured to operate redundantly. In the event of signal degradation or failure in one network, the system automatically switches to the alternate adapter, ensuring uninterrupted communication.

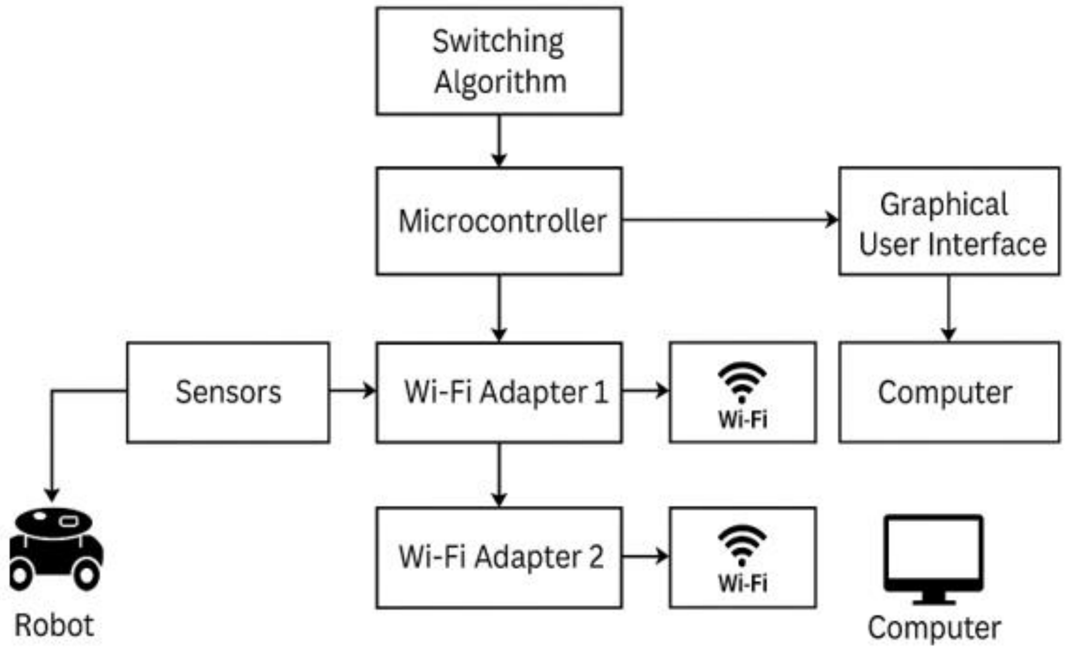

Figure 2.2.2: Block diagram of dynamic network switching module

Data Visualization and Interpretation

The data transmitted by the rover is visualized in real time through a graphical user interface (GUI), which displays environmental conditions and highlights high-priority alerts for immediate attention. The GUI is developed using Python libraries such as Tkinter or PyQT, enabling intuitive visualization through charts and color-coded indicators for different environmental parameters. A dedicated receiver unit handles the incoming data, decoding it and seamlessly pushing it to the GUI for real-time monitoring and analysis.

Proposed Methodology Flowchart

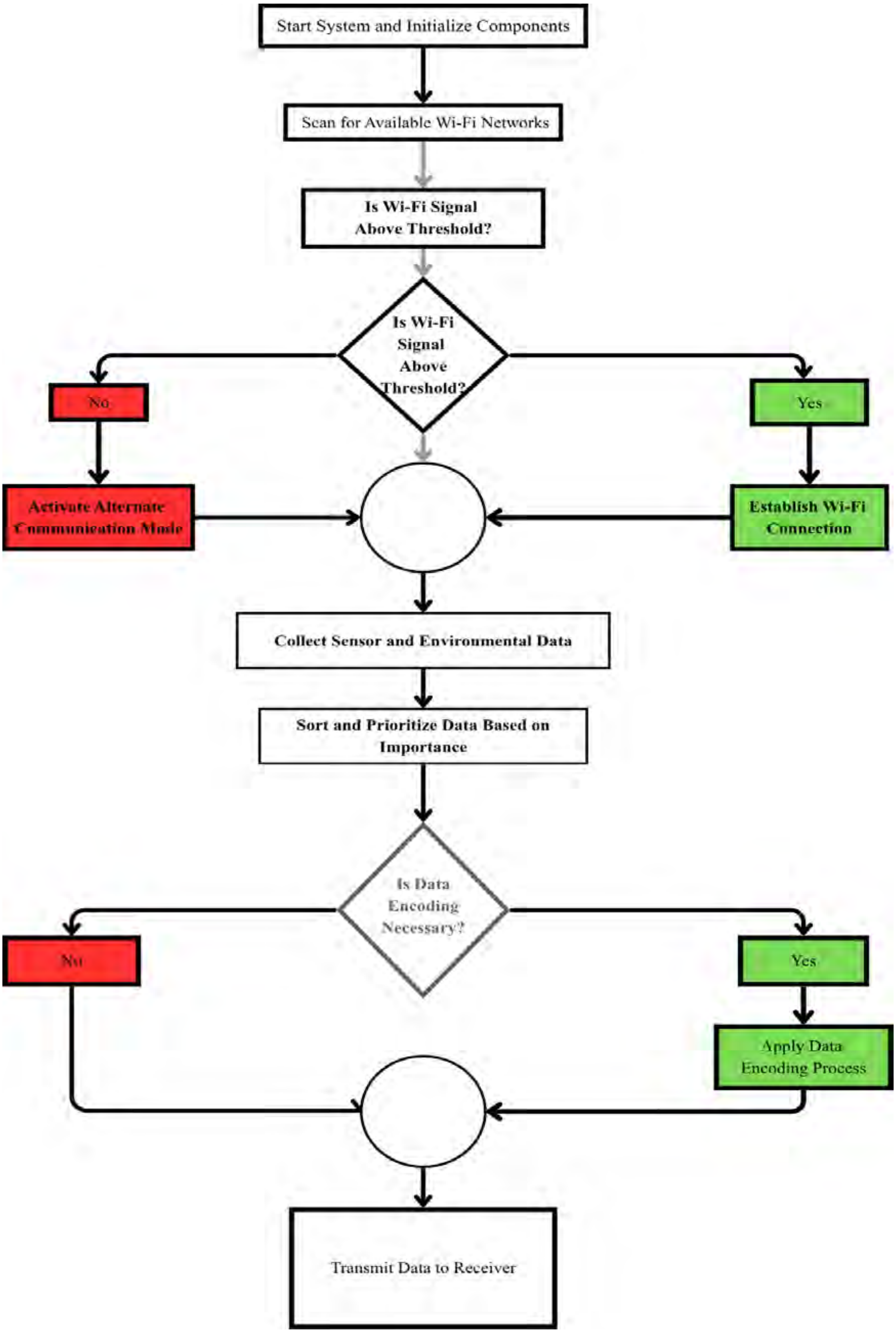

Figure 2.2.3: Flowchart of methodology

Flow Chart Summary

The methodology starts with system initialization, during which the system boots up and activates all required hardware and software components to prepare for operation. Once initialized, it proceeds to search for available Wi-Fi networks in the vicinity. The signal strength of the detected Wi-Fi is then evaluated; if the connection is strong enough, the system establishes communication through Wi-Fi, but in cases of weak or unstable signals, it automatically switches to Lo-Ra as a more reliable alternative. Following network establishment, the sensor array begins real-time environmental data collection, capturing a wide range of parameters essential for monitoring. To optimize transmission, the collected data is organized according to priority levels, ensuring that the most critical information is given precedence. Finally, encoding and compression techniques are applied, allowing the system to reduce data size and improve transmission efficiency without losing essential content.

2.4 Analysis of Multiple Design Approaches

To begin with, a comparative analysis between two design methods, feature metrics decided on stimulated primary data and researched secondary data, is given in Table 2.4.1.

TABLE 2.4.1. Summary of analysis of multiple design approaches

Feature	Single Adapter	Dual Adapter (Selected)
Switching Delay	High	Negligible
Packet Loss Risk	High	Low
Reliability in Interference	Low	High
Implementation Complexity	Low	Moderate
Power Consumption	Lower	Moderate (Optimized)
Scalability	Moderate	High

Technical Explanation of Switching Mechanism

The system employs real-time RSSI monitoring from both Wi-Fi adapters via a background process. Once the primary adapter's signal drops below a defined threshold (e.g., -70 dBm), the system instantly reroutes data transmission through the secondary adapter without disrupting active sessions. This logic is implemented via interrupt-driven tasks on the Arduino and ESP32 modules. The fallback and recovery mechanisms are reinforced through timeout and retry logic, ensuring data continuity during transitions.

Cited Research Support

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[8] H. Karl and A. Willig, *Protocols and Architectures for Wireless Sensor Networks*. Chichester, U.K.: Wiley, 2005.

[4] S. Misra, I. Woungang, and S. C. Misra, *Guide to Wireless Sensor Networks*. London, U.K.: Springer, 2009.

[10] A. Willig, K. Matheus, and A. Wolisz, "Wireless technology in industrial networks," *Proc. IEEE*, vol. 93, no. 6, pp. 1130–1151, Jun. 2005.

2.5 Conclusion

The dual Wi-Fi adapter design is a robust and efficient solution that addresses the limitations of traditional single adapter systems. Through detailed evaluation, simulation, and experimental trials, this architecture has proven to offer greater reliability, smoother transitions, and minimal data loss—qualities crucial for network-reliant robotic systems operating in smart industrial environments. This design aligns with modern communication reliability standards and provides a solid foundation for scalable deployment.

Chapter 3: Use of Modern Engineering and IT Tools[CO9]

3.1 Introduction

While looking for the selected problem and comparing between optimal solutions, the project team took decisions. Decisions, made on the ground of engineering studies, stimulation and analysis. For this, the project team relied on modern engineering and IT tools. From stimulating the switching process to making GUI interface, the project team introduced with ample of modern engineering tools. Moreover, selection process of these tools according to task is also a mentionable part of the whole project. In this chapter, the modern engineering and IT tools are mentioned with the tasks served by the tools. Furthermore, discussion on the reasoning and purpose of selection is also included in further parts of this chapter.

3.2 Selection of Appropriate Modern Engineering and IT Tools

To begin, the project team selected the tools focusing on three major concerns. They are.

1) Hardware Compatibility

2) Ease of Integration

3) Community Support

Selected tools are mentioned in Table 3.2.1 with the purpose served by the tool.

Table 3.2.1: Summary of appropriate engineering and IT tools

Tool/Software	Purpose
Arduino IDE	Microcontroller programming (Arduino Mega)
Python (Tkinter)	GUI development and real-time visualization
Wireshark	Packet analysis and network diagnostics
MATLAB	Simulation and design validation (optional stage)
Excel/Google Sheets	Data analysis and graph generation

3.3 Use of Modern Engineering & IT Tools.

Modern engineering & IT Tools used in this project is given below with the compatibility and tasks served by the tools.

- **Arduino IDE:** Used extensively to program the microcontroller (Arduino Mega), the core of the robotic system. It handles data acquisition from sensors (CO, SO2, Temperature, Humidity) and controls signal communication through the Wi-Fi adapters.
- **Python (Tkinter GUI):** A user-friendly GUI was created using Tkinter. This visual interface displays real-time data streamed from the robot to a host PC. The GUI also includes notification systems that alert users of network switching events and environmental anomalies (e.g., gas threshold exceedance).
- **Wireshark:** Used to analyze network behavior during testing phases. It provided insights into packet loss rates, switching delays, and adapter interface behavior, especially during signal degradation and failover.
- **MATLAB (Optional/Initial Simulation):** Employed in the early stages for theoretical modeling of network switching logic and potential latency calculation. MATLAB Simulink blocks helped simulate decision-making algorithms before implementation.
- **Excel/Google Sheets:** Data exported from the GUI was logged into spreadsheets for deeper analysis. Graphs such as Packet Loss vs. RSSI, and Switching Timeline charts were created to support project findings.

3.4 Conclusion

In this project, the team have extensively programmed a microcontroller to handle data sensing & collection. To add on, network based stimulation and result graphs have been added in different parts of the project report. To conduct this type of operation and collecting results, the project heavily relied on Matlab, Simulink, Arduino IDE tools. To analyze the network components, the project team used Wireshark and finally, to record and graphing, MS Excel is used. In this chapter, the project team documented all the relevant engineering and IT tools used. The broaden discussion of the tool and how it contributed in the work is also added for further clarity.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution [CO7]

4.1 Introduction

Firstly, the project team started with two optimal design approaches. To find the optimal solution from this two approaches, the project team optimized the stimulation of the design approaches. Optimization of this capitalized the idea of project teams' finding the optimal solution with higher performance, budget-feasibility and stable system. In this optimization process, the team evaluated multiple communication tactics and choosing the best, depending on latency, packet-loss, reliability and power consumption. In this chapter it is discussed how the whole process of optimization and evaluation of the best solution have been chosen for and industrial solution.

4.2 Optimization of Multiple Design Approaches

In this chapter, discussion on both the design approach will be thoroughly put. The project team came up with some verdicts about both the approaches after the whole research based knowledge and stimulation based analysis. For instance, separate block diagram has been generated by the project team for both design approaches. In further part of this chapter, block diagrams of both approaches have been elaborated in comparative manner. After that, stimulation by the alternate design approach have also been executed to validate the approaches.

As, the project team aims to find an optimal replacement of a traditional methodology, the traditional method was also optimized to find the error and short comings. After that, the second have been optimized in such manner that fulfills the short comings of the first method. In both the cases, the data collection and transmission in real time have been found which is one of the key objectives of this project. Two design approaches, considered for the primary selection is given below with the stimulation and ground knowledge.

- **Single Wi-Fi Adapter Switching**: Simple, Cost-efficient, probabilistic to delays and data loss. (during access point handover)
- **Dual Wi-Fi Adapter Switching (Proposed)**: Complex design, reduced latency and packet loss, redundant and dynamic switching enabled.

Single Wi-Fi Adapter Switching

To begin with, the traditional single Wi-Fi Adapter Switching, is operated in a linear manner. If the singular path of communication is hampered by any mean, the whole system gets paused for a while which can eventually cause system loss. To elaborate the working principle of this approach, a block diagram is given below:

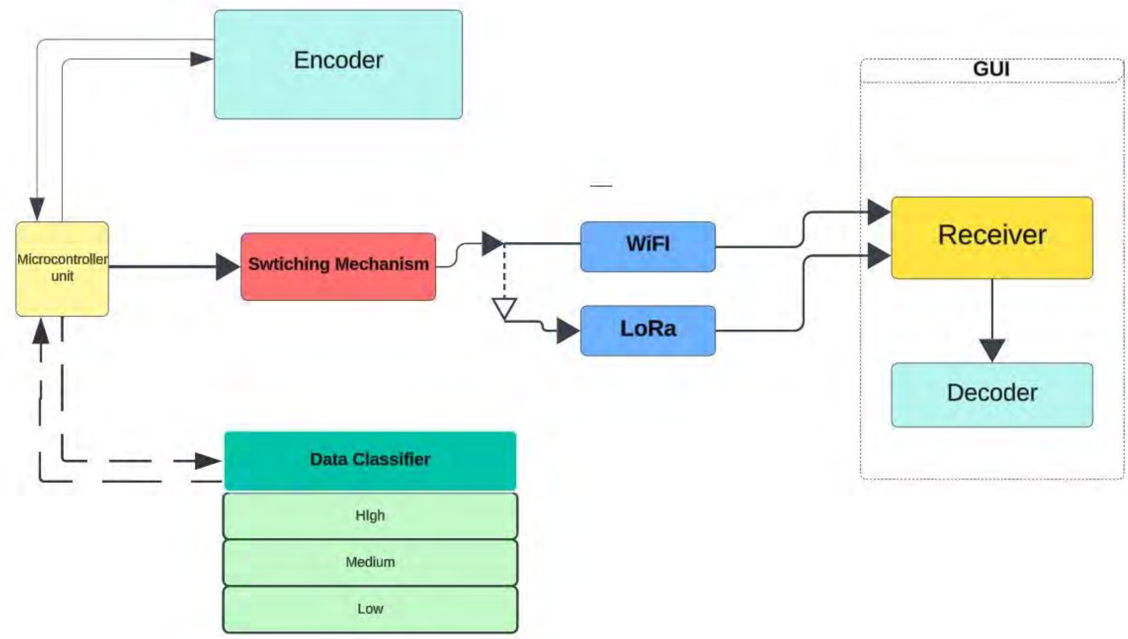

Figure 4.2.1: Block diagram of approach A (single adapter switching).

In this block diagram, the communication lines elaborate graphically how the data packets are moving in one direction relying on one data transmission path. If this path of transmission from switching block to Wi-Fi and Lo-Ra block gets blocked, the whole system is malfunctioned. Relying on this one path, even the switching time gets increased, higher latency and packet drop.

The **Input Block** generates simulated sensor data. such as CO_2, PM2.5, temperature, and humidity, at 0.5 second intervals within an industrial-like range, providing continuous input for further processing. The **Classification Block** then evaluates these readings to assign priority levels according to predefined conditions, marking extreme environmental values as high priority and normal readings as medium or low. Finally, the **Signal Strength Generation Block** produces random signal strength percentages for available networks, accounting for possible dead zones and outputting corresponding network indices for subsequent analysis.

Moreover, the project team have also stimulated this whole scenario in Simulink so that it the metrics can be properly compared in between the two approaches. Here, the stimulation diagram of the design approach is attached.

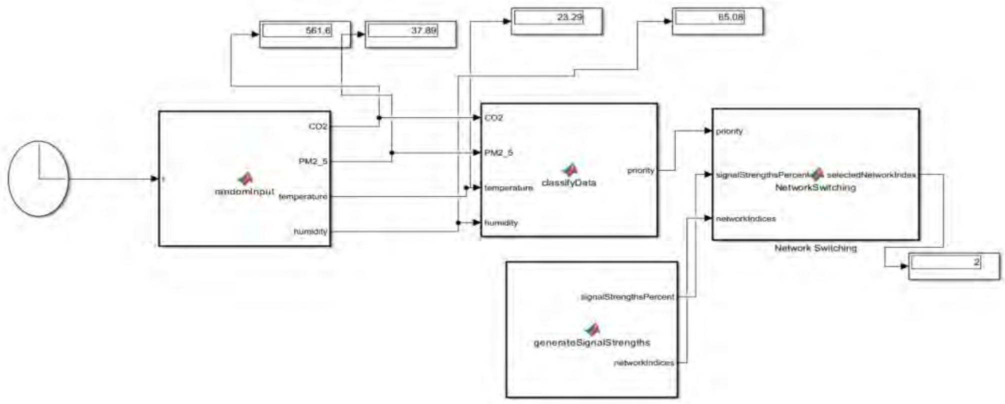

Figure 4.2.2: Simulink stimulation of approach A (single adapter switching).

In the stimulation diagram we can see the sensor functioning and giving real time data values in the above. Moreover, from the middle right display we can see the switching mechanism working. But, in the case of failure all of these variables came with null value, due to network downtime.

Dual Wi-Fi Adapter Switching

On the contrary, in the dual Wi-Fi adapter switching module, there are two individual channel of communication. In this way, the system communication can be stayed upright in one of the channel of communication. As a result, the system stays on seamlessly. The probable rate of latency, downtime and packet loss gets lessened. To make it more clear, the block diagram is given.

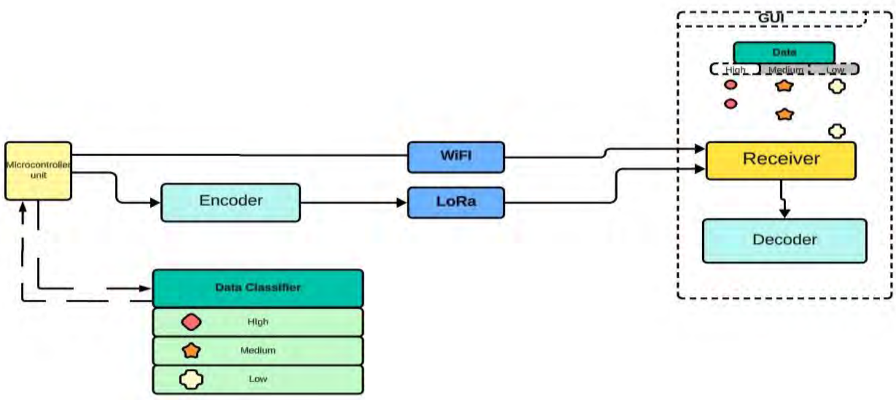

Figure 4.2.3: Block diagram of approach B (dual adapter switching).

Now, to stimulate the knowledge gained from the research, the project team created a virtual environment of method B.to analyze the system with the variable metrics. Moreover, the functionality of the design approach can also be debriefed by the Simulink stimulation of the Design Approach B.

The **Input Block** simulates real-time industrial sensor data for CO_2, PM2.5, temperature, and humidity, generating random readings every 0.5 seconds within predefined ranges and passing them to subsequent processing stages. The **Classification Block** analyzes these inputs to assign priority levels based on environmental thresholds, marking severe conditions as high priority and normal ranges as medium or low. Finally, the **Signal Strength Generation Block** produces random network signal strength percentages according to predefined parameters and possible dead zones, outputting network indices for further processing and selection.

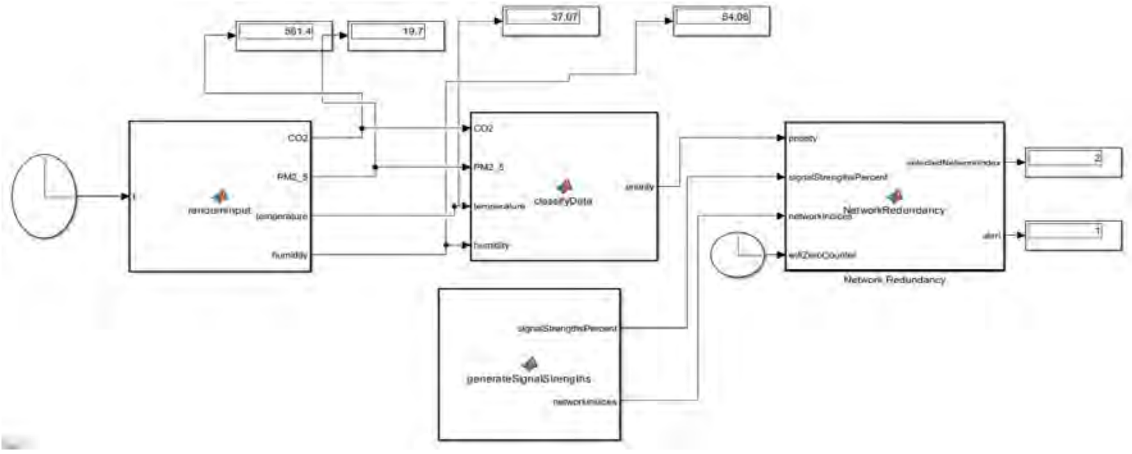

Figure 4.2.4: Simulink stimulation of approach B (dual adapter switching).

In this stimulation diagram, first findings are same as the first approach. But, the addition of the second adapter comes with the failover feature. Here, during the network downtime the system stays on and in the first display of the middle right shows the network path index (2) which is the second adapter used to transmit the data. Display just below it, shows the alert for the faulty adaptor (1).

4.3 Identification of Optimal Design Approach

After thorough optimization of multiple design approaches, the project team recorded the comparison between two design approaches in Table 02. From the comparison and field condition analysis, the project team analyzed following criterion to identify method B: Dual Wi-Fi adapter switching as the best optimal solution.

- **Seamless Communication:** With Dual adapter, handover can be done without discontinuity in connection.
- **Reduced Packet Loss:** Almost zero packet loss comparing high spikes in single adaptor.
- **Stable Latency:** Average latency below 50ms which is lower than method 01.
- **Power-Efficiency:** With the high rate of power consumption, implemented adaptive switching algorithms reduce the excess usage.

4.4 Performance Evaluation of Developed Solution

At this chapter, the project team took the stimulated data range of the Simulink and entered the data into Matlab. From Matlab, the project team generated charts which clearly stimulate the network switching mechanism as well as the comparative analysis between two approaches in different metric under consideration.

Firstly, the project team validates the system under the handover latency comparison,

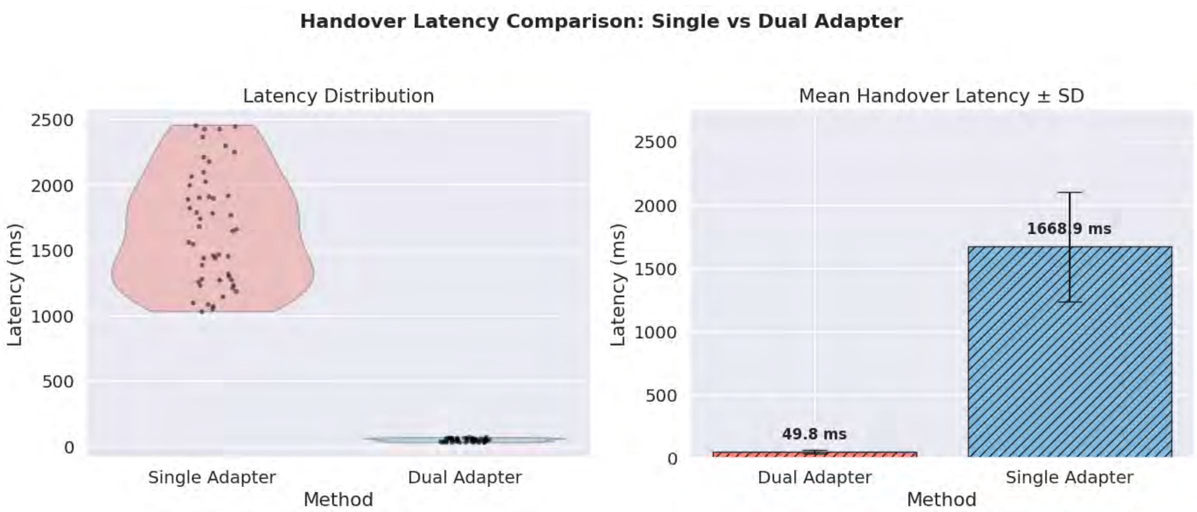

Figure 4.3.1: Handover latency comparison

In this comparison, we can see less latency occurring in dual adapter as well as the rate of latency very improved than single adapter.

The following visual comparison shows significant latency improvement with the dual adapter design:

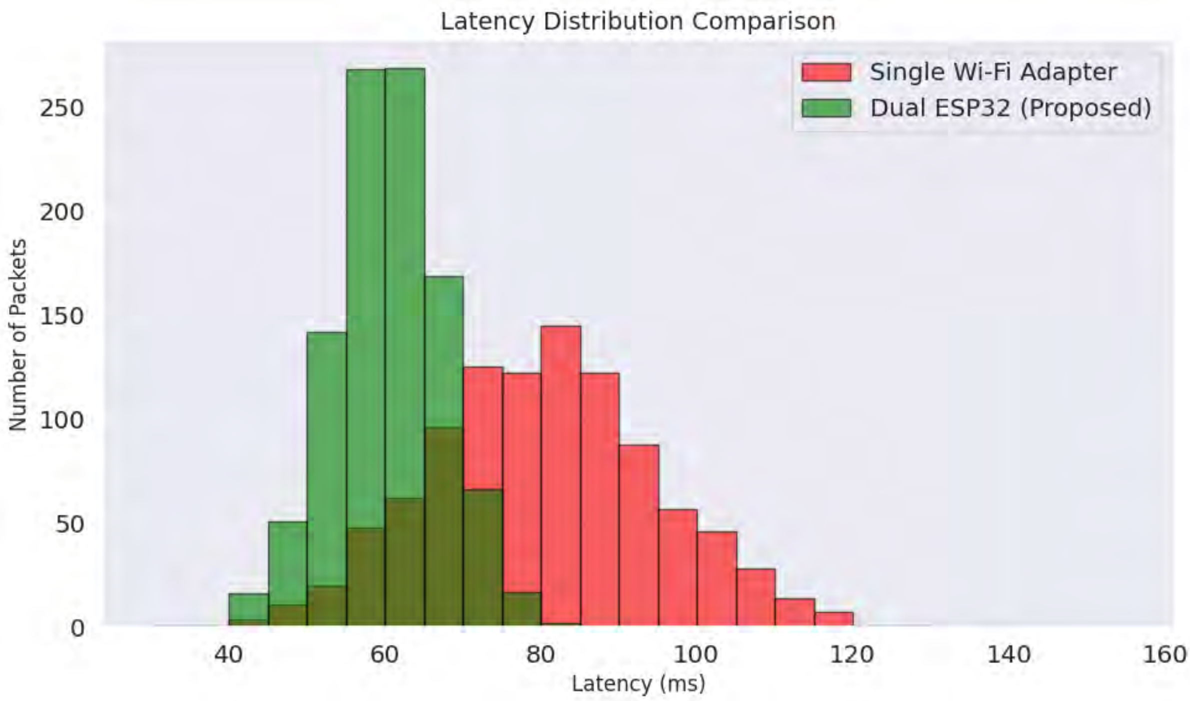

Figure 4.3.2: Latency distribution across adapters

A histogram further illustrates that latency is more consistent and minimal in the dual adapter model:

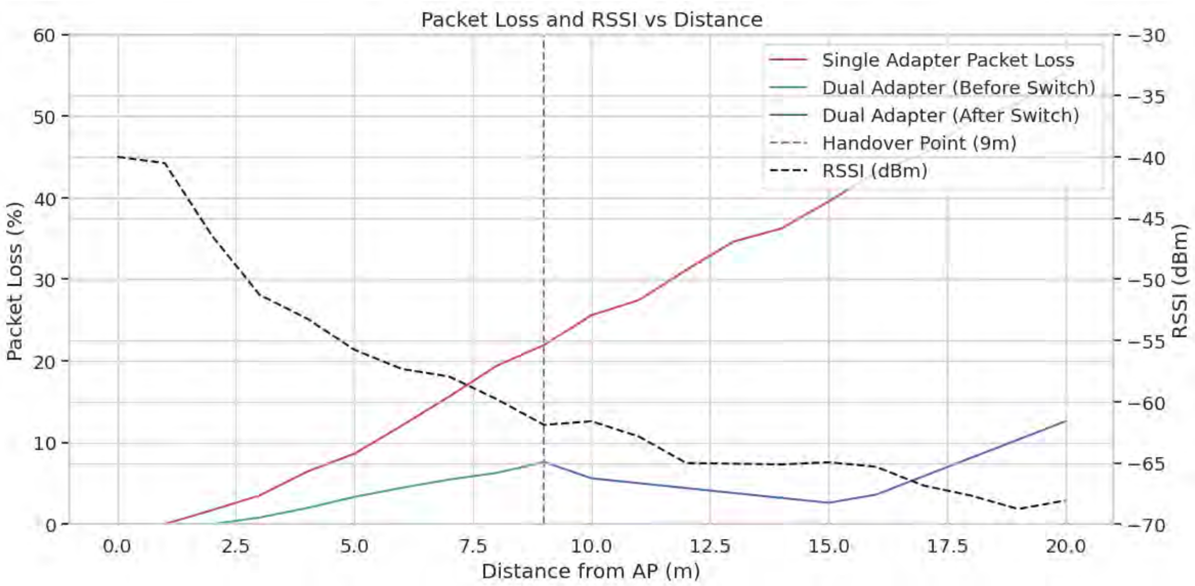

Figure 4.3.3: Packet loss and RSSI vs distance

As shown below, packet loss increases with distance in single adapter mode, whereas the dual adapter system maintains stability due to proactive switching:

Figure 4.3.4: Adapter switching timeline with packet loss markers

This timeline illustrates automatic switching between adapters with real-time packet loss detection:

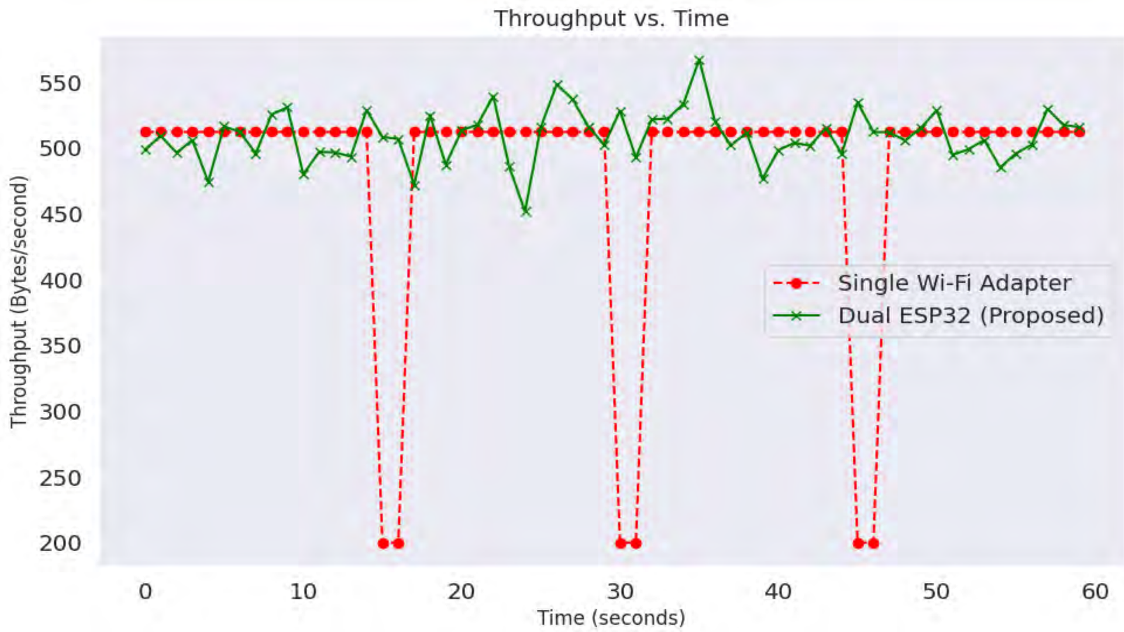

Figure 4.3.5: Throughput vs. time comparison

The proposed dual adapter design delivers more consistent throughput by avoiding the dropouts seen in the single adapter system.

Following the above visuals, the system consisting dual Wi-Fi adapter performs better than traditional method of signal switching. Firstly, this proposed system of dual Wi-Fi adapter system bot is offering optimized throughput time. Secondly, improved packet loss is impacting the user compatibility in a good number of 0.3% every minute. Thirdly, latency rate is also showing a number of 49.8ms in comparison of 1668ms in single adaptor which is also an improvement.

With the result showing developed system in this project in better communication reliability, the project team giving verdict of the dual Wi-Fi adapter design as the better solution. It is a robust solution catering the limitation of traditional single adapter systems. In this chapter, detailed evaluation of the comparative analysis between design approaches, stimulation and experimental trials of the system architecture have been documented in a convincing manner. To conclude, the final features of the system is greater reliability and minimal data loss, which is highly impactful for robotic system operation in smart industrial environments.

4.5 Conclusion

After thoroughly testing the iterative test cases and tuning the parameters, the project team concluded in this manner that, the dual Wi-Fi adapter switching design is the optimal solution of the chosen network problem. The optimal solution provides lessened data loss, comparatively stable performance in noisy environment and real-time data analysis. Following outcomes directly collide with CO7 with a systematic design optimized with real world benchmark constraints and performance.

Chapter 5: Completion of Final Design and Validation [CO8]

5.1 Introduction

In this chapter, the findings and short comings of the whole project is going to be discussed. Completion of a project in a functional way refers to the combined functionality of the system, aligning with the preset requirement and goals. In this project, the system combined with dual Wi-Fi Communication system, Sensor Array and line following robot performs seamlessly at real-time data monitoring in GUI along with autonomous mobility. In the next sections, elaborated discussion of the process, components and the outputs of the project is mentioned with prototype images.

5.2 Completion of Final Design

To begin with, in this project the project team started with multiple components with different purpose and specification. Due to time, budget, hardware compatibility, algorithmic complexity constrains, the project team has to get rid of some components. Finally, the core equipment modules used in the final design projects are given below:

- **Arduino Mega Microcontroller**: Coordinates sensor data collection, signal processing, and hardware control.
- **Dual ESP32-Based Wi-Fi Adapters**: Provide seamless switching between networks based on RSSI levels.
- **Sensor Array**: Includes CO, SO_2, temperature, humidity, and barometric pressure sensors.
- **Line Following System**: IR sensors guide autonomous movement along predefined paths.
- **Motor Drivers and Chassis Assembly**: Allow for mobility and stability in indoor factory settings.
- **Graphical User Interface (GUI)**: Developed in Python (Tkinter), it displays real-time environmental data, alerts, and system logs.

In this final prototype hardware and software have been integrated in cognitive manner so that the prototype can be implement directly in industrial environment for monitoring and autonomous operation. In the following parts of this chapter some highlights of the prototype completion will be discussed.

Integration of ESP32 Modules with Arduino Mega

After comparing with Raspberry pi, Arduino, the project team finalized Arduino Mega as the central coordinator for handling sensor inputs, motor control and GUI data formatting. The project team dual ESP32 in a client server handshake mechanism, in which one of them was kept standby, while the other adaptor was active. Synchronization was achieved using UART with the MEGA polling RSSI from both ESP32s. At the time of adapter's RSSI drop below the threshold mark, an interrupt signal is being sent by MEGA to trigger adapter switching within 80-100ms.

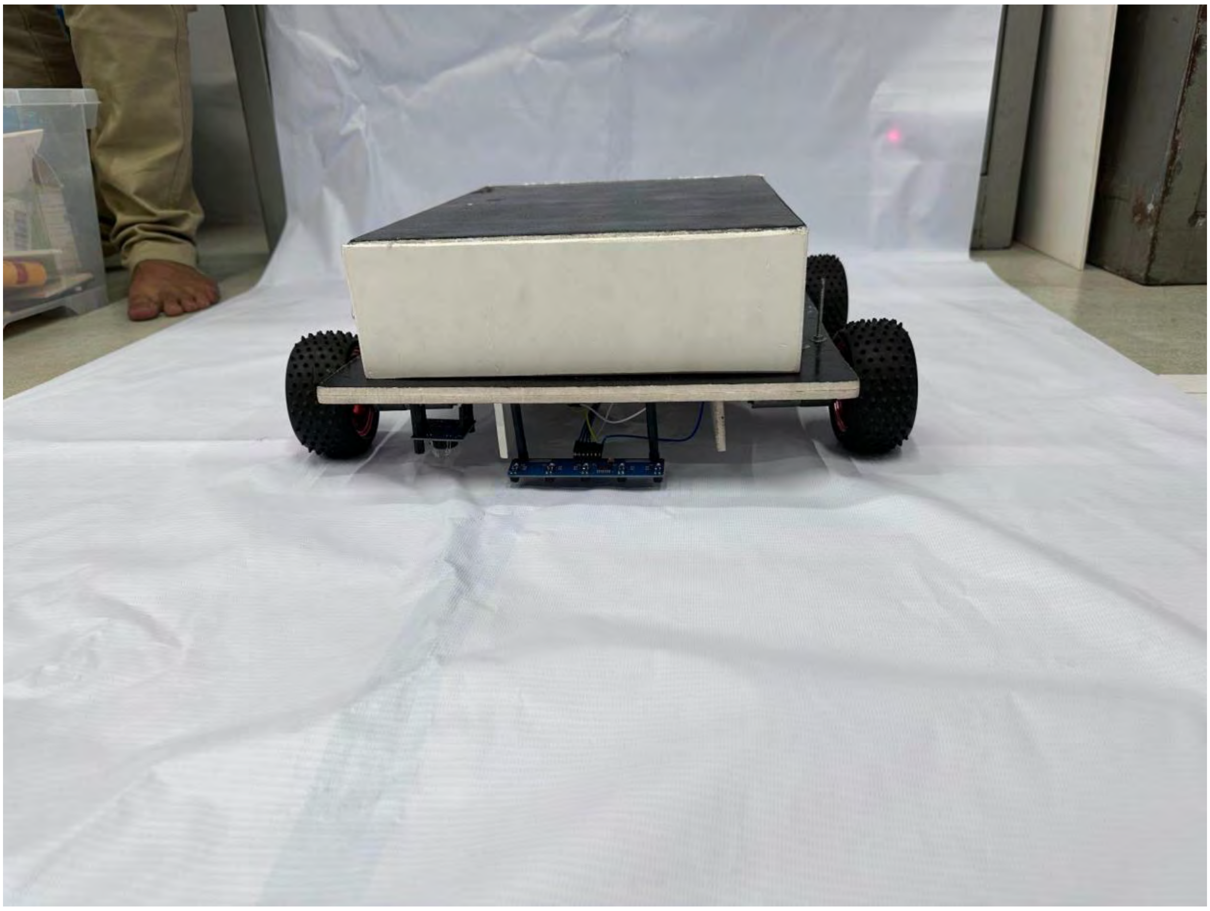

Figure 5.2.1: Prototype front view.

Power Distribution Across Sensors and Motors

To ensure stable operation, power was distributed using a modular PCB with segregated rails. The sensor array was supplied with 5 V regulated lines, while the ESP32 modules received 3.3 V through onboard voltage regulators. Motors and drivers were connected to a separate rail supported by the rechargeable power bank, preventing voltage drops during peak loads. Decoupling capacitors were placed near sensitive sensors to minimize noise from motor spikes.

Prototype Characteristics:

- **Weight:** The complete robot weighed approximately 1.6 kg, making it light enough for mobility while remaining stable during turns.
- **Dimensions:** 28 cm × 22 cm × 15 cm (L × W × H).
- **Battery Runtime:** The system operated continuously for an average of 37 minutes on a single full charge of the compact power bank.
- **Mobility:** The chassis incorporated a balanced wheel design with dual DC motors, achieving smooth navigation on industrial floors with minor surface irregularities.

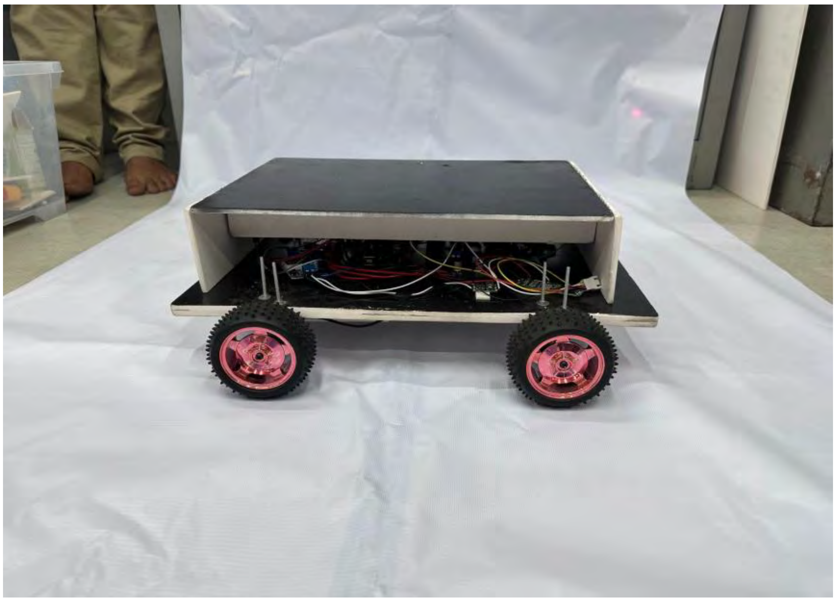

Figure 5.2.2: Prototype side view 1

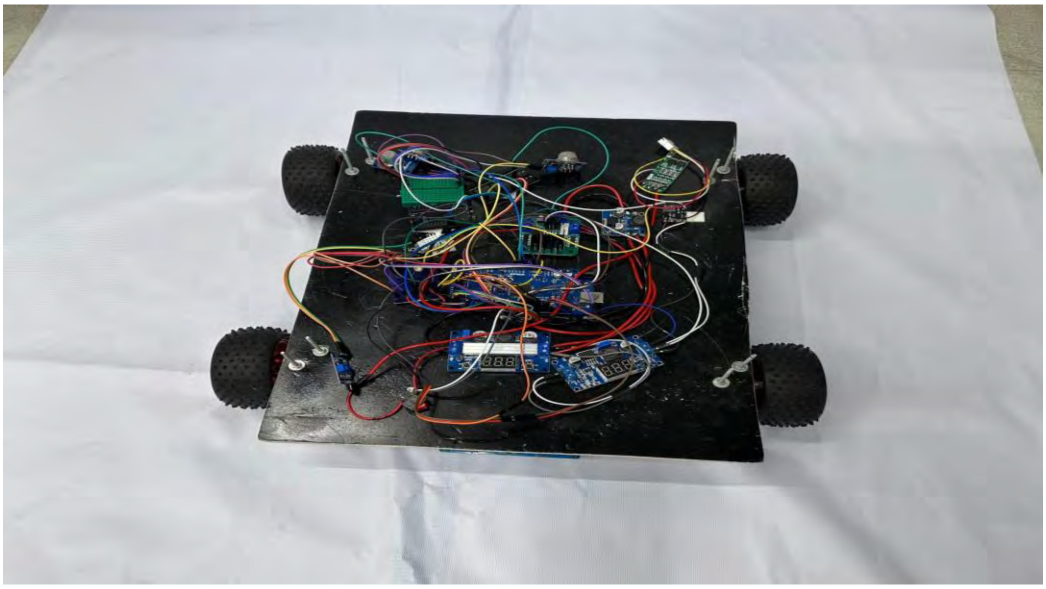

Figure 5.2.3: System view showing hardware layout

Implementation of line following and segment switching

The implementation of line following and segment switching was not merely a navigation feature but a critical demonstration of the robot's capacity to operate autonomously in structured industrial environments. The line following system, based on an array of IR sensors, enabled the robot to detect and remain aligned with predefined floor markings. This ensured that mobility, reflecting the predictable movement patterns required in factory settings. Beyond simple tracking, the integration of segment switching illustrated the robot's decision-making ability, where transitions between distinct track sections were executed dynamically without manual intervention.

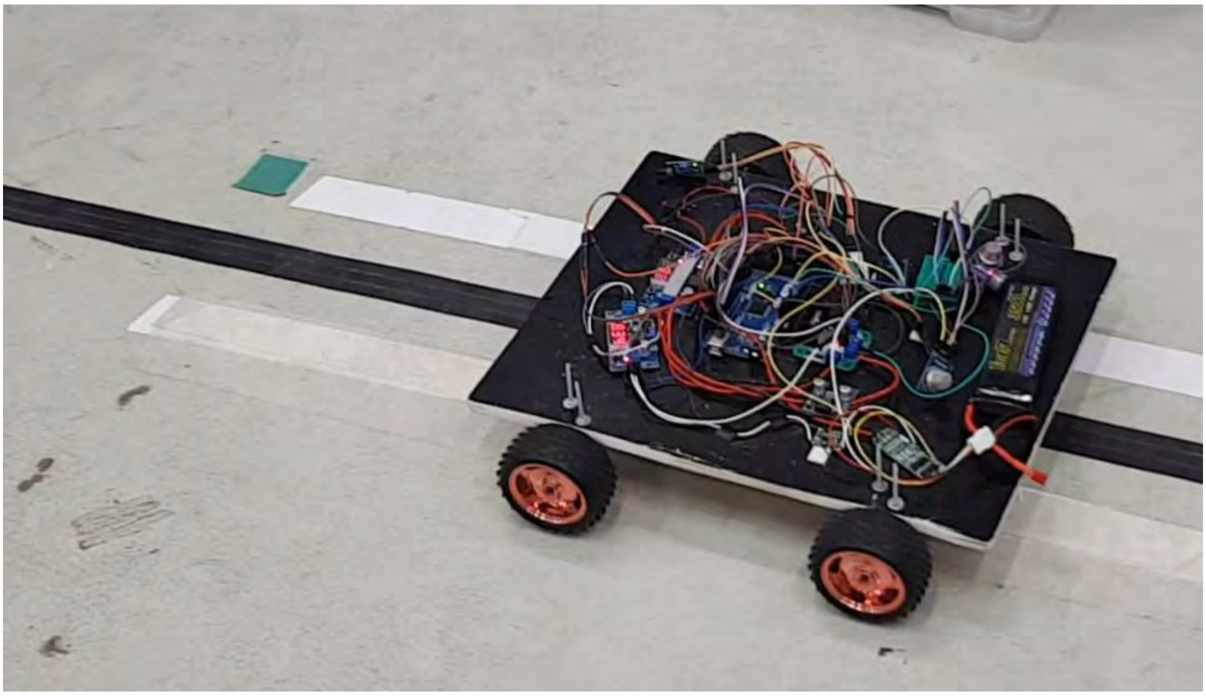

Figure 5.2.4: Line following test in progress

To demonstrate this experiment, the project team three different stations and a ground station. Firstly, the bot starts moving from the ground station and move till the first station which is when both the ESP32 are showing stable result. In the next station which is slightly visible in the Figure 5.4 is our far green station where the system switches to the alternate adaptor as in that station primary ESP32 gets disconnected. At that station, the system works accurately by executing the switching in between 80-100 ms and moving forward till the next station. In the third station which is colored in red the bot take a short pause and move rightwards. After an interval of 100ms the autonomous robot completes the same routine of action and returns back to the ground station.

GUI Platform Demonstration

As mentioned in various section of this project report, HMI for the prototype robot will be established by the project team. In this section, the demonstration and working principle, and how it has been designed by the project group will be discussed. In the following discussion, firstly, a brief knowledge about the Python's Tkinter and GUI development process is discussed according to the project requirements.

Firstly, the project team imported the Tkinter and PySerial libraries and initialized the main GUI window. After that, the project team created basic frames and labels. To fetch raw data streams, the project team opened a serial connection with the Arduino Mega and ESP32. Secondly, the project team implemented parsing functions to split the incoming serial data into two section: environmental readings (temperature, humidity, pressure, gas levels) and network statistics (latency, packet loss, adapter switching). Finally, the project team added exception handling for serial errors, and run multiple test cycles by simulating Wi-Fi disconnections and failover events to confirm that the GUI reflects changes instantly. Three project requirements have been capitalized by this design approach which is give below.

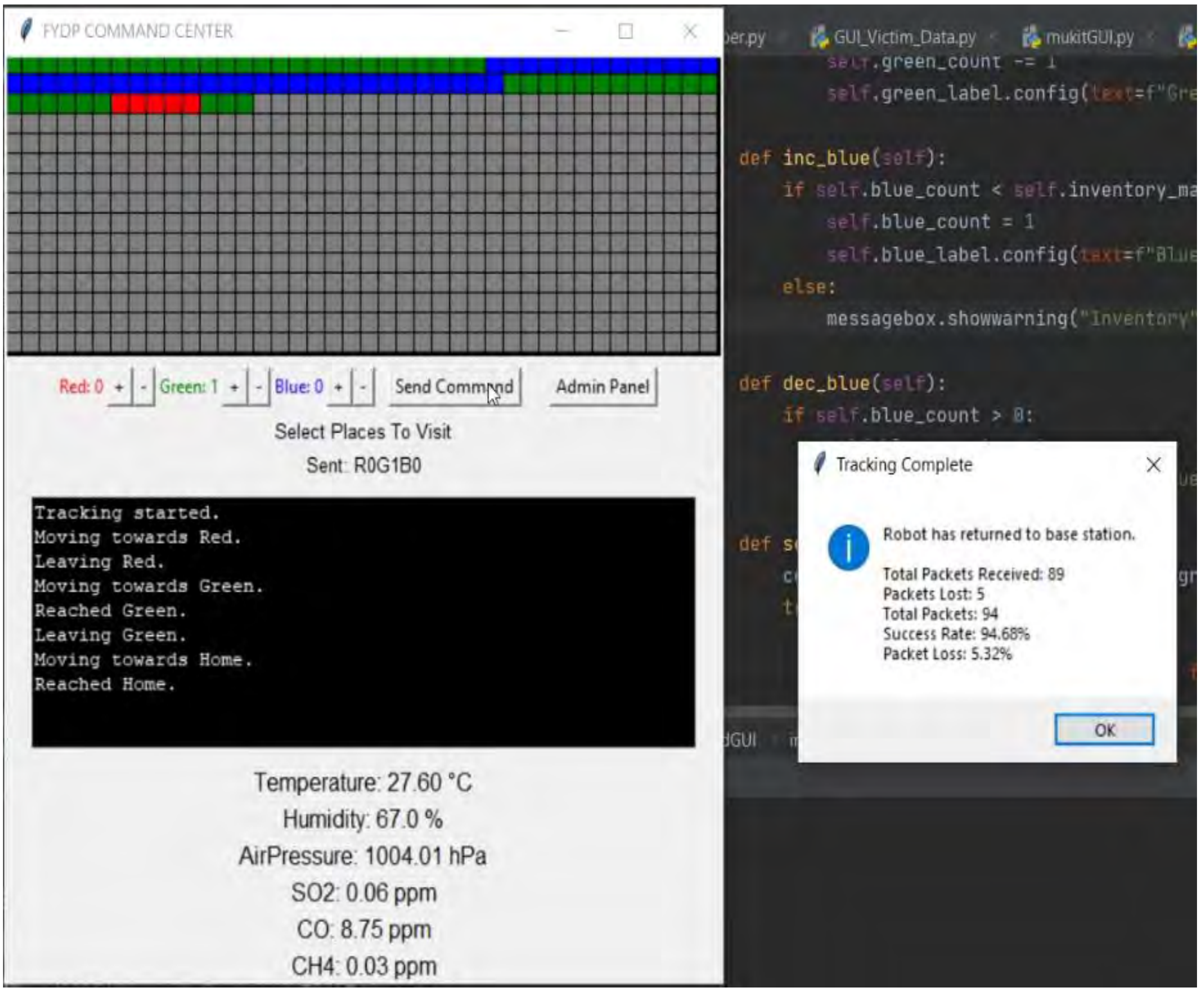

Figure 5.2.5: GUI during sensor data collection with adapter switching.

The demonstrated GUI Interface acts as the central monitoring platform not only can visualize the readings of the active sensors in the AGV, but also give insights on network statistics and system sates in real time.

1) Sensor Data Visualization: The project team used multiple sensors which is actively collecting environmental data and show them in this interface. In the fig 5.2.5 we can see some data metrics of environment with the real time measurements such as Temperature, Humidity, Air pressure, SO2, CO, CH4 etc. with units. By this AGV this metrics can be calculated and observed in more real time and in bigger radius as the AGV is capable of hovering around the whole industrial environment.

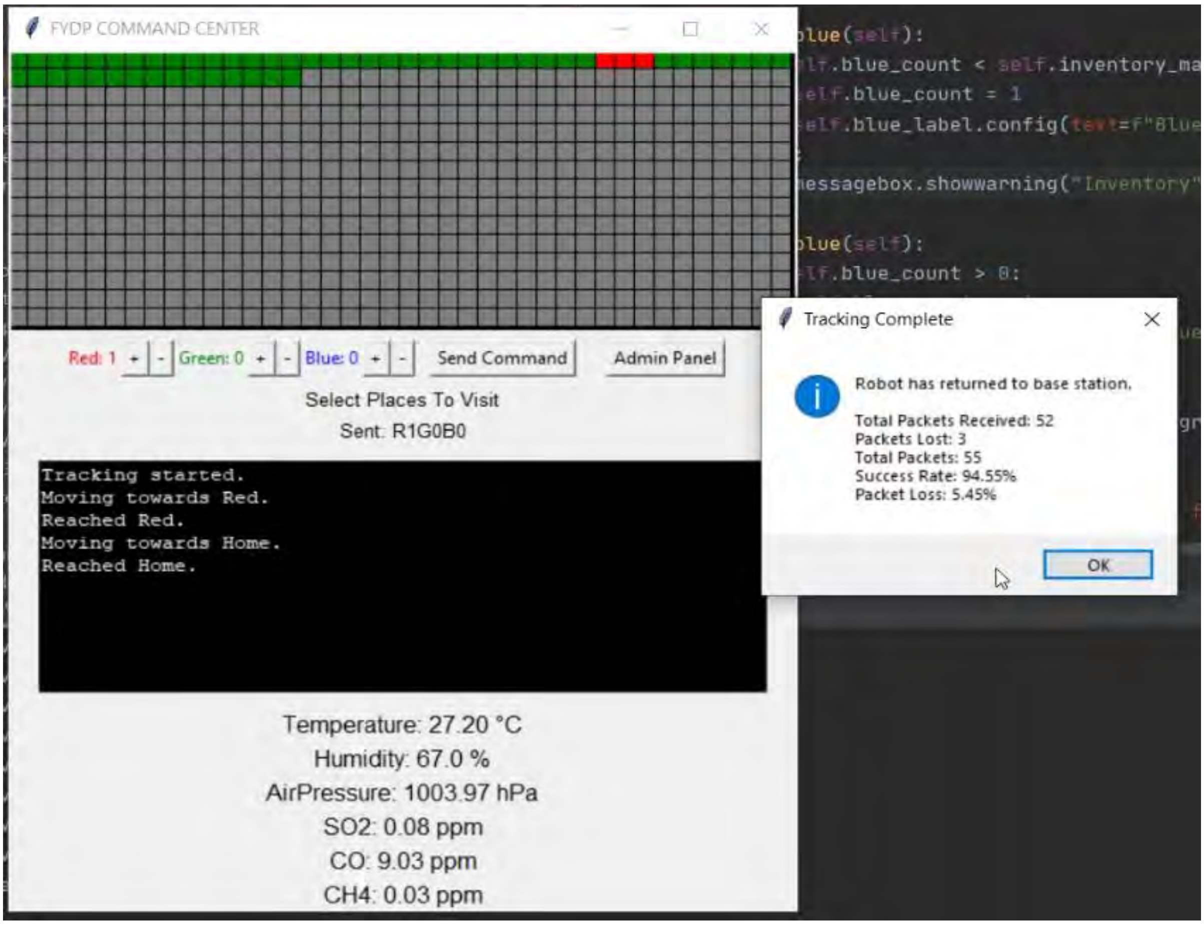

Figure 5.2.6: GUI output showing packet statistics

2) Network Adaptor Switching Indication: The GUI continuously monitors the active communication adapter. During a failover event, the interface highlights the change from primary Wi-Fi to backup communication (Lo-Ra or secondary router), ensuring transparency in the system's redundancy mechanism. Moreover, inclusion of this functionality, the maintenance operation in the industrial zone will be more easy and smooth. As, the interface shows the faulty adaptors as well as network dead zones. In the figure 5.2.6, the GUI showing output packet statistics, where we can see a reduced packet loss of 5.45 % in between 55 packets. Thus, the solution meets the statement of providing reduced packet loss. To add on, real time monitoring of network subsidiaries are also accomplished by this interface which is shown in the figure 5.2.6.

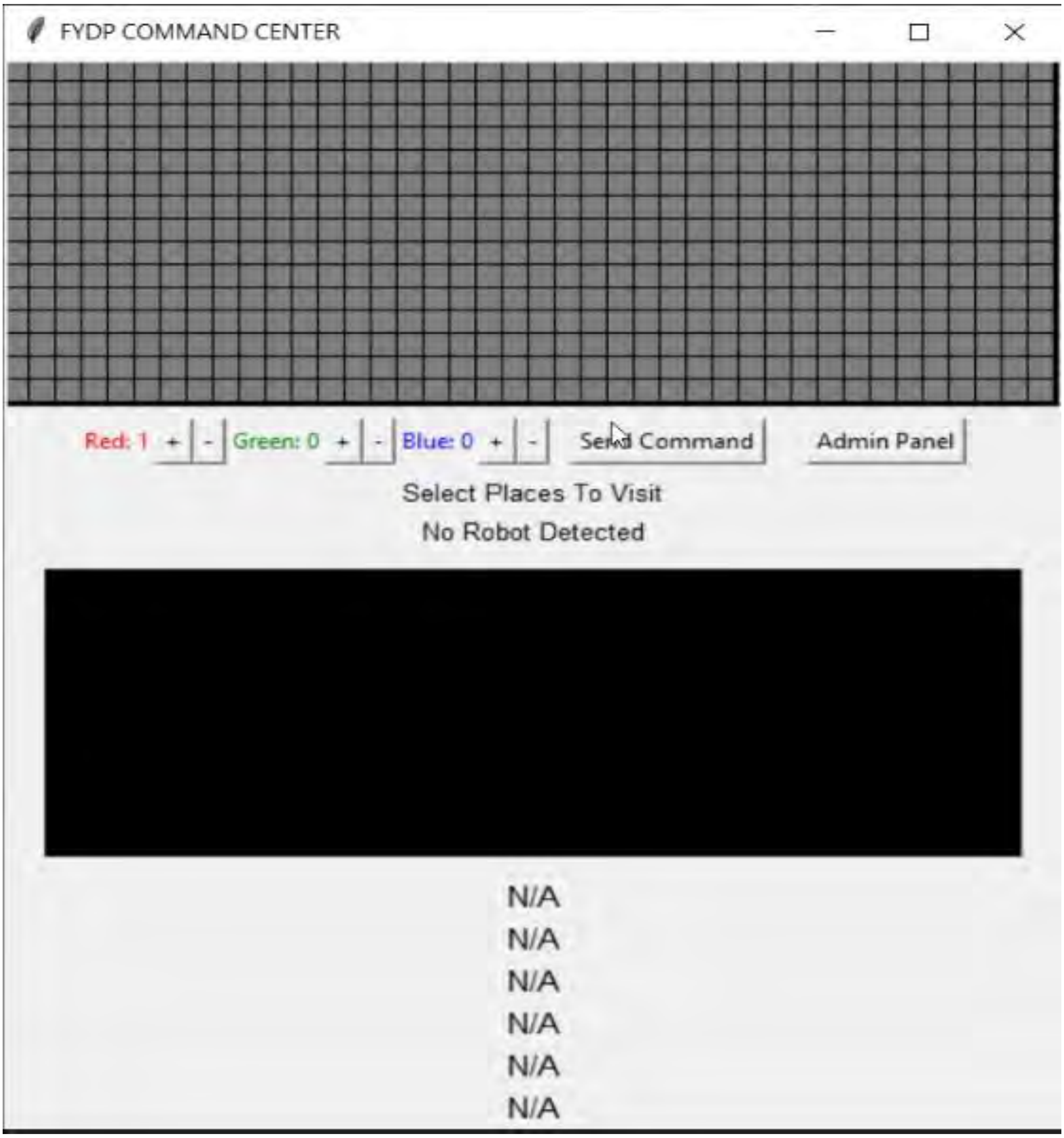

Figure 5.7: GUI state without active robot detection

3) System and Robot Status Feedback: The final prototype of this project is an autonomous line following AGV. To have a control of the AGV and track the actions of it, the project team included features to the GUI interface. The GUI provides clear visual indicators for packet statistics, network latency, packet loss ratio, and robot presence/absence. This allows the operator to detect anomalies quickly and take corrective action. In the figure 5.2.6, there is a detailed section where updates on every station is updating chronologically. For instance, when the AGV starts to move, the interface shows tracking started. To continue, with the AGV moving towards red and arriving at the red station, the interface shows 'moving towards red, leaving red, moving towards green, reached green' etc. Thus, the interface gives proper feedback in real time by which the status and system can be recorded and initialized properly and traced in the interface.

5.3 Evaluation of the Solution to Meet Desired Needs

System validation was carried out in several key stages. Firstly, descriptive narration by the project team given under experimental observation and key findings. The key features, specification and data inputs are listed below in a descriptive manner:

- **Functional Accuracy**: Each sensor's data output was verified using benchmark test environments to ensure accurate measurement of CO, SO_2, temperature, humidity, and pressure.
- **Network Responsiveness**: During live demonstrations, switching between adapters occurred within 80–100 ms of signal degradation.
- **Environmental Robustness**: Tests were conducted under variable lighting, temperature, and signal interference conditions to validate system reliability.
- **GUI Effectiveness**: The GUI was stress-tested for responsiveness and stability while displaying live data. Alerts were triggered accurately when thresholds were exceeded.
- **User-Centered Design**: The robot's interface was evaluated by external observers for usability and clarity, especially in industrial monitoring scenarios.

Each subsystem—wireless communication, motion, sensing, and user interface—was rigorously validated before final integration, ensuring minimal error propagation.

Secondly, to validate the solution more statistically and showcase the observed data found in this project experiment, the project team compared them with target benchmarks set at the very beginning. After descriptive analysis and graphical prototype completion, comparison table has also been executed and recorded.

The objectives of this project was to meet certain goals such as. Designing a dual WI-Fi adapter system which can ensure uninterrupted communication, creating a signal based switching algorithm, collecting real time environmental data and finally, developing an integrated GUI for operator interaction. In this chapter, the discussion on various sections of completion of the project shows how the system is capable of doing all of these. The project team demonstrated algorithm and prototype capable of switching stations and adaptors. To add on, the GUI interaction media have enlisted real time data collection. Though, the project team aimed to illustrate an industrial robot capable of working itself. Due to the constrains mentioned in chapter 02, the project team defocused to that and demonstrated a smart industrial bot which is autonomous, which can monitor real time data and finally switch between Wi-Fi adaptors according to their RSSI.

In the table, the project team showed how the observed metrics met with the target benchmarks of varied parameters. Remarks of the practical experiments are also included in the table. The table included below adds validation to the narrations stated above in the descriptive part.

Table 5.3: Quantitative summary of validation parameters

Validation Parameters	*Target Benchmark	Observed Performance	Compliance Status	Remarks
CO Sensor Accuracy	±9 ppm	±8.7 ppm	✓ Met	Stable readings
SO2 Sensor Accuracy	±3 ppm	±0.9 ppm	✓ Met	Stable readings
Line Following Deviation	≤2.0 cm	1.2 cm	✓ Met	Smooth navigation on test track
Network Switching Latency	≤100 ms	82 ms (average)	✓ Met	Seamless Transition
GUI Response Time	≤200 ms	170 ms	✓ Met	Data logs updated in real time
Temperature Measurement	±31.0 °C	±27.1 °C	✓ Met	Consistent with room temperature
Packet Loss in Transmission	≤2 %	0.80%	✓ Met	Under interference, stable connection

*The target benchmark numbers are experimental values experienced by the system in the FYDP Lab and the ideal stimulation results found on secondary sources.

5.4 Conclusion

In the final prototype, the project team demonstrated successful integration of hardware, software and user interface components altogether. As a robust industrial network solution, the prototype meets all the core functional requirement such as uninterrupted connectivity, continuous environmental data collection, monitoring based user interface and autonomous path-finding. In this chapter, images of implementation and outputs have been included. After the following results and outputs, project team evaluated the solution to meet the targeted objectives with data and analysis. To conclude, the prototype of this project align with the challenges of CO8 by the completion of a functional industrial communication solution.

Chapter 6: Impact Analysis and Project Sustainability [CO3, CO4]

6.1 Introduction

A project has not only technical impact, but also other impacts such as. social, environmental, health and operational impacts. In this chapter, the project team found out these key impacts of this project to analyze the overall sustainability. In fact, the sustainability is broadly examined using engineering perception and a discrete SWOT analysis framework. This chapter will give an overview of the impacts and sustainability of this project in real life scenarios.

6.2 Assessment of the Impact of the Solution

The proposed system positively impacts several critical domains:

- **Societal Impact**: By reducing the dependency on manual monitoring in industrial environments, the system enhances productivity, allows reallocation of human resources to less hazardous tasks, and fosters the upskilling of workers. It supports smarter, safer industrial automation aligned with Industry 4.0.

- **Health and Safety Impact**: By this industrial robot, the air quality of any given environment can be monitored right before hazardous condition, an early caution to avoid long-term damage. Therefore, a safer workspace.

- **Operational Impact**: The dual adapter design ensures robust wireless connectivity, minimizing downtime in data collection and control processes. This improves operational efficiency, especially in large industrial zones with weak signal zones.

- **Technological Advancement**: Integrating real-time wireless switching, sensor fusion, and GUI-based monitoring promotes the adoption of scalable, modular robotic platforms in smart factories.

6.3 Evaluation of the Sustainability

A sustainability evaluation was carried out through SWOT analysis and observation of long-term environmental and economic effects.

Strengths: Mentioned project is aimed towards energy efficient switching logic in which only one Wi-Fi adapter transmits at a time. By this, the energy used for multiple routers is saved. Secondly, this project offers improved safety and extended productivity which are major key needs in industrial environments. Thirdly, the modularity and scalability of the system architecture which is unique and backed by communication engineering. These are the key strengths of this project which establishes the feasibility of this project in the current market.

Weaknesses: To begin with, the initial need of cash deployment can be major concern regarding this project. To implicate this technology in a large scale of industry, will need a big manufacturing unit and further infrastructure which is a weakness. Secondly, the current stakeholder and their lack of willingness in adaptability is another clear weakness of this project. Transforming their human labor based industries to a 4.0 grade industry will take a lot of awareness and adaptability at the side of stakeholders which is another weakness of this project.

Opportunities: Firstly, with the ongoing Industrial 4.0 revolution, a smart communication supported industrial itself is an opportunistic phantom. Moreover, the customizable capacity according to industry specific tasks is add on to the opportunity of this project. Secondly, this project is also suitable for future innovation with IoT cloud systems. With this, further features such as surveillance and resource tracking can be enabled in the industrial territory which is another tremendous opportunity of this project.

Threats: To begin with, discussion on the competitive technology and relevant market entry is very necessary. The technology focused in this project is very time appealing and already big players are merging in this market. This is one of the optimal threat which can be fought with proper funding and gradual research based improvement. Secondly, the economic constrains are the biggest threat in this project as this project lies in the prototype level. To implement the technology from the research to real industrial scenario will need a humongous amount of funding which can be considered as the second threat of this project.

Table 6.3: SWOT analysis

SWOT Analysis	
Strengths	**Weaknesses**
• Energy-efficient Switching Logic • Improve Safety & Productivity • Scalable & Modular System	• Initial Capital Burn • Lack of Awareness among Stakeholders.
Opportunities	**Threats**
• Customization with industry requisition • Collaborative Innovation with IoT & ML Technology	• Competitive Technology • Relevant Market Entry • Financial & Legal Constraints

\

Environmental Considerations:

- Parallel solution as human-aid in monitoring and managerial tasks.
- Eco-friendly industrial practices.

6.4 Conclusion

Further reading of the above discussion, the project team can come across an end line of several substantial benefits across safety, efficiency, environmental stability and economic validity. Moreover, in both the case of short and long-term impact, the solution shows strong credibility with CO3 and CO4. Furthermore, the project is modular, scalable and adaptive of various engineering and robotics core studies. Finally, after all the analysis and impact under consideration, a verdict can be announced, this project with varied impact will sustain with proper guidelines.

Chapter 7: Engineering Project Management [CO11, CO14]

7.1 Introduction

Management in engineering projects is defined by the administrative course of action, in which the whole project is being monitored and executed. Engineering project management is taught before in an academic course to maintain the integrity of managerial process of the project. In this project, team have applied those learnings and methods of engineering project management. As a result, the project ended in between the timeline. Moreover, at any given phase of the project the team along with the supervisors could track the progress of the project. According to that the team was given instructions and acting on those feedbacks, the project came out successful. The principles, timeline, tools, milestones and the progress evaluation of this project have been discussed in this chapter.

7.2 Definition, Planning and Management of Engineering Project

Across the academic year of 2024-2025, this project has been designed in 3 phases. Planning (FYDP-P), Design (FYDP-D), Completion (FYDP-C). The whole project is managed by university final year students and supervised under ATC panel. This project was organized from the scratch in planning phase, executed from the best outcome in the design phase and recorded the final outcomes and documentation in the completion phase. In the ending of this Chapter 7, project group have included the detailed Gantt chart of the whole project timeline.

Firstly, here is the detailed overview of the project with targeted tasks.

Project Phases Overview

- **FYDP-P (June–September):** Literature review, requirements and constraints finding, feasibility analysis, component selection and finalization.
- **FYDP-D (October–January):** Hardware integration, Wi-Fi switching algorithm development, sensor testing, GUI prototype.
- **FYDP-C (February–April):** Final testing, performance validation, poster presentation, report writing.

Human Resource Management is also a revolutionary idea for making a project work in a tight schedule, making best use of the resources. Associated members of this project group can be considered as the primary human resources of this project. ATC Panel committee and FYDP Coordinating Committee is the supervision managerial board of the project, the task given to the project team was maintained through Google Classroom and in the project group the following steps and credentials have been maintained throughout the project. The human resource management and timeline management overview is given below:

Task Management & Resource Allocation

At first, the project team planned a course of action according to the project objectives and goals. Then following those actions, separate roadmap of tasks for FYDP-P, FYDP-D, and FYDP-C have been established by the team. After that, team listed the tasks and oriented them according to priority and timeline. Team tasks were divided according to task checklist in between the timeline. (e.g., hardware, software, documentation). To maintain the clarity of communication and record, separate mail thread has been used in between the group members.

Moreover, to comply with the supervisors, once in a week (every Wednesday) ATC Meeting have been held in the Department premises. Weekly progress reviews (held with ATC panel) are recorded and maintained in the log book. As, the team had to collect varied components. To check the availability and best prices of the components, team communicated with multiple vendors. Component procurement is briefly discussed and recorded with vendor paperwork. After the collection inventory paperwork have also been recorded and maintained to optimize the resources properly. To record and maintain this paperwork and timeline the used varied popular tools such as: Trello (task tracking), Excel (budget management & Log Book), and GitHub (code collaboration).

Risk Management and Contingency Plan

The process of discovering, evaluating, and mitigating risks to a project is known as risk management. A comprehensive framework allows a project to analyze all of the potential risks. During the development of our project, we identified some potential risks which can be hazardous to the stability of our project. Those are-

Faulty Electrical Connection: Ensuring your system design includes fail-safe mechanisms like backup power, grounding, and surge protection for smooth switching.

Motor Failure: Your system can include predictive maintenance algorithms using data from edge computing to alert the team before failure.

Access Point Overload: Since you're working on optimizing bandwidth, consider load balancing techniques as part of your design to automatically reroute communication.

Security Breach: Ensure your network protocols are robust and that intrusion detection systems are integrated into your solution.

Radiation Risks: If using Wi-Fi or cellular signals, RF exposure is a concern. Incorporating shielding and proper equipment placement can help mitigate this. Environmental Factors: Installing environmental monitoring and rugged hardware suited to industrial conditions will mitigate environmental risk.

Table 7.2.1: Risk intensity metrics

Sl No.	Risk Event	Likelihood	Severity	Contingency Plan	Management Procedure
1	**Faulty Electrical Connection**	Medium	High	Switch to backup power, perform immediate repairs	Regular electrical inspections, ensure proper wiring, surge protection
2	**Motor Failure**	Low	High	Replace motor with a backup, stop the bot temporarily	Routine motor maintenance, keep spare parts on-site
3	**Overload of Access Points**	Medium	High	Reduce non-critical traffic, reroute bot communication to alternative access points	Monitor network traffic and optimize load balancing across access points
4	**Security Breach**	Medium	High	Disconnect affected systems, initiate incident response plan	Implement firewalls, intrusion detection systems (IDS), and regular security audits
5	**Radiation Risks Associated with Micro Signal Communication**	Low	Medium	Relocate workers, add shielding, reduce signal strength	Conduct RF exposure assessments, follow regulatory exposure limits, enforce PPE where necessary
6	**Environmental Factors**	Medium	Medium	Halt operations, relocate bots, and initiate cooling or cleanup	Use industrial-grade equipment, install environmental monitoring sensors, schedule regular cleaning and maintenance

7.3 Evaluate Project Progress

As mentioned above, the project team started their journey by establishing project goals which are termed as Key Progress Indicators. Project milestones were evaluated using predefined KPIs such as:

- Completion of hardware integration by December
- Dual-adapter switching demonstration before final week of January
- Sensor accuracy and GUI validation by mid-March

Peer evaluations and supervisor feedback ensured quality control and identified bottlenecks. Mid-phase adjustments were made to optimize adapter switching logic based on real-world testing. With the kpi's in consideration the project team merged the peer evaluation and feedbacks with utmost urgency, so that the deliverable goals can be met in between the timeline. All those efforts came in action at the end. By the end of FYDP-C, the project had met its functional and deliverable goals, such as: Successful implementation of dual Wi-Fi adapter switching, GUI integration with real-time sensor feedback, Validation of data transmission under varying signal conditions

7.4 Conclusion

To conclude, this project has been accomplished with a full phase operational, consisting final year engineering peers and professors. To maintain clear and hustle free collaboration and work flow management, the team maintained widely used management tools such as (Log Book, Gantt Chart etc.) Role Distribution and evaluation metrics have been maintained in a regular basis to obtain human resource management. These concludes with the core project management tools and core ideas used in this project. By maintaining them in mentioned manner, the team came across a successful project completion in between the timeline which exemplify the application of CO11 and CO14.

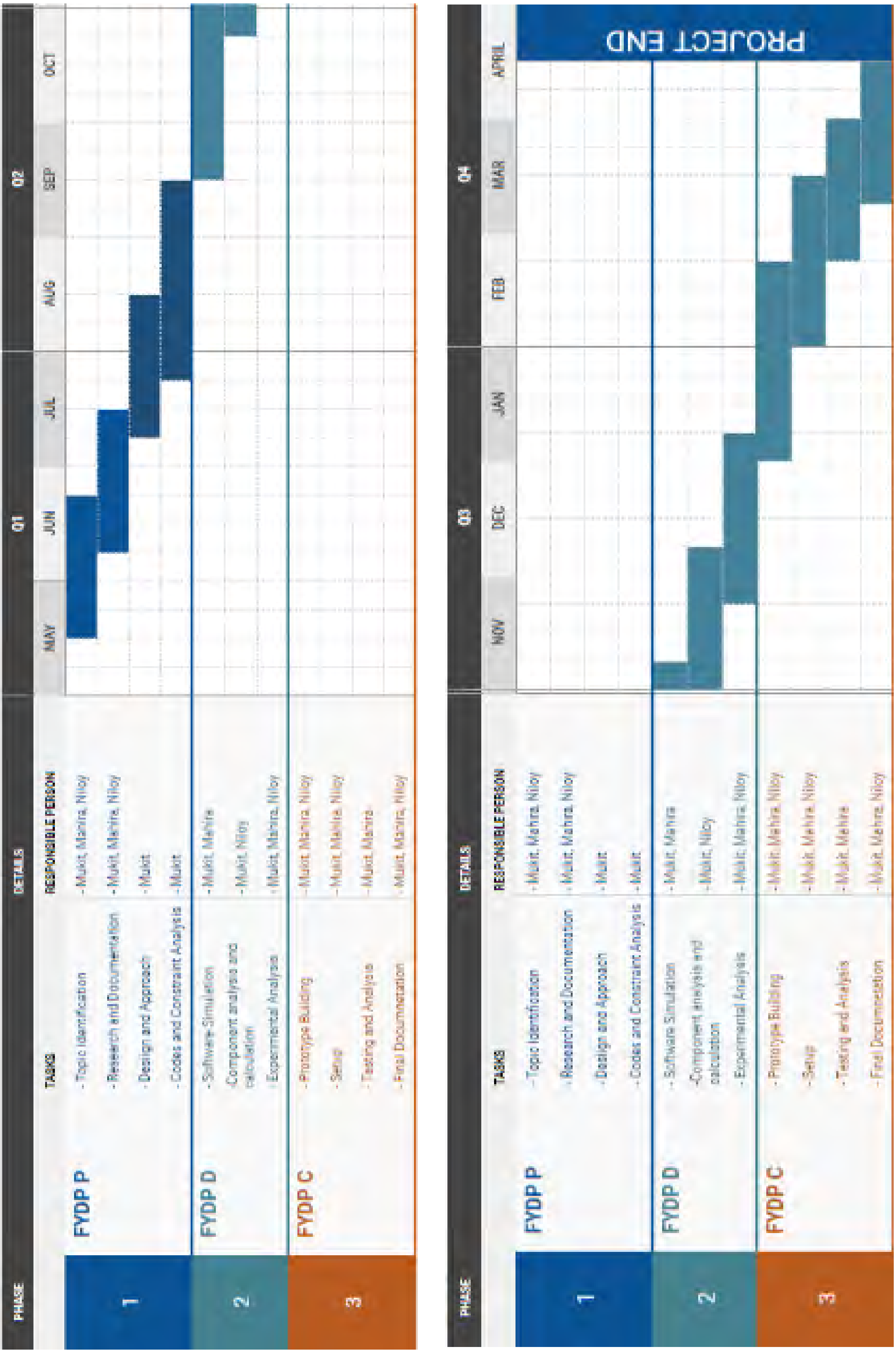

Figure 7.4.1: Gantt chart of FYDP with timeline.

Chapter 8: Economical Analysis [CO12]

8.1 Introduction

Economic Analysis, a decisive metric in engineering project evaluation. To ensure the financial feasibility as well as cost-effectiveness and affordability of this project. This chapter of the project have been thoroughly analyzed in which a broad breakdown of the cost structure, value proposition and sustainability evaluation can be visualized. In the further sections of the chapter the analysis methods and financial calculations have been recorded with the numbers and final analysis coming from the calculation. These feedback decisions of the calculation worked as the fuel to complete this project.

8.2 Economic Analysis

To begin with the economic analysis, the first recorded all the expenditures of the project. There is given two individual tables for Project Cost Breakdown & Hardware Cost Breakdown below:

Table 8.2.1: Project cost breakdown

Cost Sector	Expenditure(BDT)
Hardware & Components	8000
Labor & Build	2000
Total Initial Costing	10000
Proximate Selling Price	18000

Table 8.2.2: Hardware breakdown

Component Name	Column1	Price (BDT)
Arduino Mega Microcontroller	1	1,200
ESP32 Wi-Fi Module	2	1,000
CO Sensor	1	500
SO_2 Sensor (MiCS-5524)	1	1,200
Temperature & Humidity Sensor (DHT22)	1	500
Barometric Pressure Sensor (BMP280)	1	400
IR Line Following Sensor (TCRT5000)	3	450
Motor Driver Module (L298N or similar)	2	800
Chassis with Motors	1	1,500
Transport		450
Total		8,000

Software Tools

- Open-source platforms (Arduino IDE, Python, Tkinter GUI) were used to minimize cost.

8.3 Cost-Benefit Analysis

Cost Benefit Analysis is defined as a ratio of the manufacturing cost value and the optimal benefit value of the project. Firstly, From Table 8.1 & 8.2, the cost of the project is measured. After that, project team have tried to analyze the optimal benefits from this project by calculating the resource saved from the hardware implementation.

Manufacturing Cost: In a monetary timeline of 1 year and estimated market timeline of 3 years, here is the discrete breakdowns of the initials cost

Equipment & Machinery: 8000 BDT

Lab utilities and Consumables: FYDP Laboratory, Brac University

Maintenance Costs:

Servicing & Spare Parts: 2000 BDT

Estimated Benefits:

Reduced Downtime: In the timeline of 3 years, one industrial unit can save estimated downtime of 15,120 BDT

Labor/Time Saving: 14 BDT/day

Net Present Value Projection:
With these value of benefits Net Present Value of this project can be calculated, which is given below:

$$NPV = \sum \frac{(Benefit_t - Cost_t)}{(1+r)^t} = \frac{15120-12000}{(1+0.02)^3} = 2943.39 \text{ BDT}$$

Cost-Benefit Ratio Projection and Analysis:

$$BCR = \frac{Present\ Value\ of\ Benefits}{Present\ Value\ of\ Costs} = \frac{15120}{12000} = 1.26 \text{ ; profitable when BCR>1.}$$

Return on Investment (ROI) Projections:

- Estimated ROI: **80%** for a single unit over 3 years.

- Potential for ROI to exceed **120%** in bulk production (100+ units), where unit cost reduces to 8,000 BDT.

8.4 Evaluation of Economic and Financial Aspects

From a financial standpoint, the project is:

- **Affordable:** Designed with cost-effective modules to remain accessible for small-to-mid-scale industries.
- **Scalable:** Cost per unit reduces significantly with increased production scale.
- **Sustainable:** Long-term savings through reduced human labor, energy efficiency, and faster data response times.
- **Flexible for Customization:** Low reconfiguration cost to adapt to different industrial use cases.

These considerations make the design both economically viable and competitive in the industrial automation market.

8.5 Conclusion

In the economic analysis of a project, different mathematical and financial measurements are made to check the opportunity of the project. Secondly, tracking the financial records and analysis. In this chapter, the annual cost record and entities are properly determined with Pi-graphs and tables. Different analysis such as Cost-Benefit Analysis, Net Profit Value have been calculated on estimated values by the project team. To conclude, the economic analysis of this project came out successful in the calculated metrics. The narrative of economic analysis chapter ended with a profitable, affordable and marginable note.

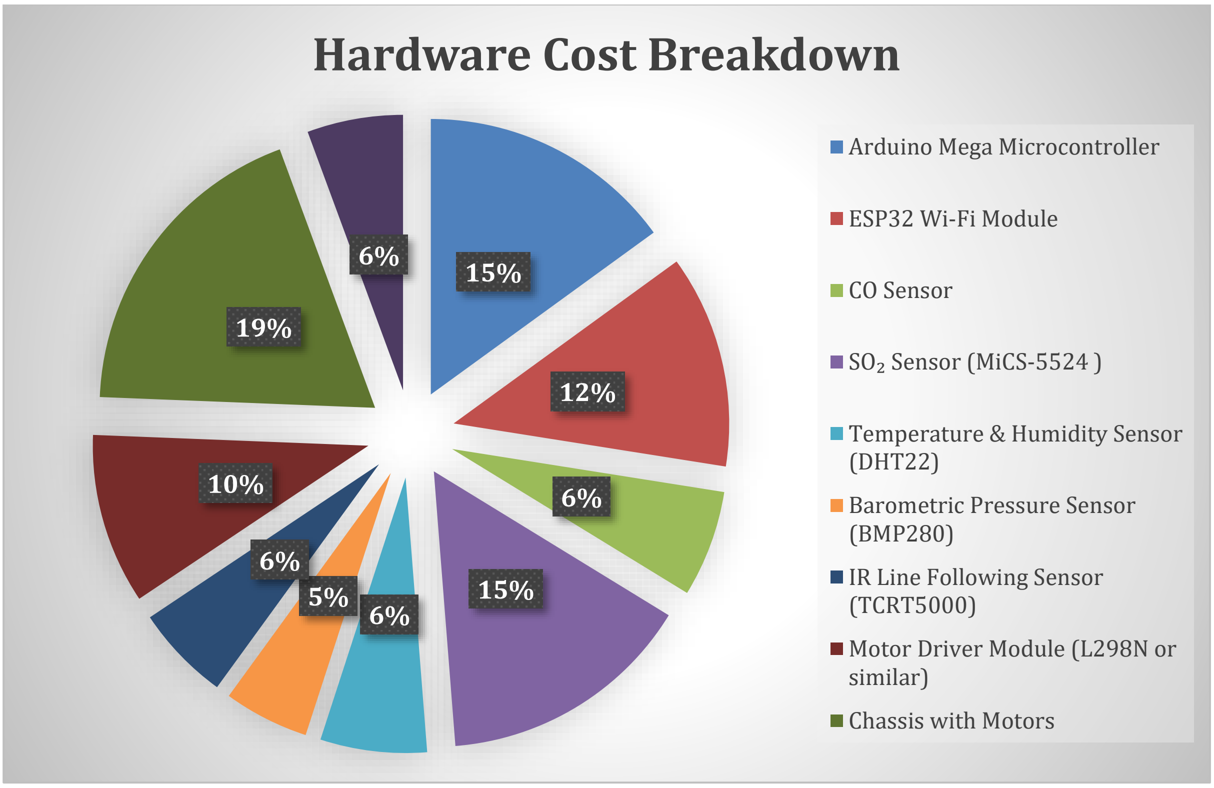

Figure 8.5.1: Hardware cost breakdown

Chapter 9: Ethics and Professional Responsibilities [CO13, CO2]

9.1 Introduction

Ethical considerations in our project are fundamental principles that must be followed during design, implementation, and throughout the project's development phases. In an Industrial Field, duty of a network professional is to keep the network system work seamlessly, finding the network errors and take action in the data and network breach. Since, this involves industrial systems, special attention must be given to data privacy, security, transparency, and regulatory compliance to ensure responsible and ethical outcomes. Working on this project, we are looking forward to keep our ethical and professional responsibility on point, mostly focused on network related privacy and ethics. At the very beginning the ethical root have been set to work with proper consent and not to break any applicable conducts and Codes.

9.2 Identify Ethical Issues and Professional Responsibility

The integrity of our engineering project mostly on the technical consideration. But, the practice in the ethical dimension is also very vital and the key ethical issues identified in our project are as follows:

1) **Data Privacy and Security**

   With the use of real-time monitoring and wireless data transmission, a risk of unauthorized access and data breaches establish in the industrial environment. Thus, protecting sensitive and inclusive data of particular industry is one of the foremost ethical & professional responsibility.

2) **Transparency and Accountability**

   The clarity in communication how the data have used and managed in the system is very necessary at the ethical lens. All stakeholders must be on the line and given access to relevant documentation in every sphere of development and deployment of this project.

3) **Ethical Use of Technology**

   The project involves communication systems that could potentially be repurposed or misused. Ensuring that the technology is applied within ethical boundaries and only for intended use cases is a significant responsibility.

4) **Regulatory Compliance**

   Adherence to relevant laws, safety standards, and industry-specific regulations is a fundamental professional duty. Failure to comply with such regulations could lead to legal consequences, operational failures, or endangerment of users.

These ethical issues are central to the project's development and deployment. Identifying them early in the design phase ensures they are appropriately managed and mitigated throughout the project's life cycle.

9.3 Apply Ethical Issues and Professional Responsibility

After identifying the ethical issues mentioned above, we applied some ethical issues and professional responsibilities have been deployed in the whole team, in every step of the project. These issues and responsibilities are mentioned below:

Ensuring Data Privacy & Cybersecurity

As the ideas of the project highly rely on real time monitoring and wireless transmission, lots of data & information is available within our accessibility. To prevent unauthorized access and breach of privacy, measures such as End-to-end encryption, personalized authentication protocols and regular security check of database have been maintained.

Maintaining Transparency & Accountability

all the stakeholders, ATC's, Groupmates and Component Vendors have been communicated with proper clarity. Moreover, we tried to maintain rationality in decision making. For this, we ensured mutual respect and verbal freedom in all decision making among all the stakeholders. Finally, we tried to do proper documentation of every financial transaction, meeting details and consent proposals.

Promoting Ethical Use of Technology

the codes and standards mentioned in the Applicable Standards & Code Section have been briefly studied by the groupmates. After repeated study and research, elaborated rules and regulations linked to this project have been selected and applied throughout the project.

Upholding Regulatory Compliances

The project team strictly maintained the lab safety, equipment safety, component safety guidelines and abide by them. Moreover, documentation of compliance consideration, such as risk management, SWOT analysis was executed at different phase of the project, which have been included in the project report in different section.

By addressing these ethical considerations throughout the whole project life cycle, the team not only mitigated risks but also set a narration of Ethical Engineering

9.4 Conclusion

Ethical Consideration in any engineering project is a vital consideration and part of a new era of Ethical Engineering. As a team of aspirant Final Year Students, our team strictly followed the measures of ethics and practiced the ethical way of engineering in our project. By following the ethical course of action, we identified some key measures of ethical consideration regarding our project such as Data Privacy, Transparency, Responsible Use of Technology and Regulatory compliances. After identifying this sectors, we tried to look for the applicable standards and policies. Finally, we set our course of action according to our learning. As a result, Project team as a unit, ensured a more secure, safe and intended use of technology and academic integrity which is contributing to a more secure and ethically grounded engineering solution.

Figure 9.4.1: Code of ethics

Chapter 10: Conclusion and Future Work

10.1 Conclusion

This project successfully designed, developed, and validated an intelligent robotic communication system that optimizes network switching and bandwidth management for indoor industrial environments. Through the integration of dual Wi-Fi adapters, real-time environmental sensors, autonomous mobility, and a GUI-based control interface, the system demonstrated robust performance across various testing scenarios. All project objectives—seamless communication, accurate sensing, efficient GUI display, and adaptive control—were achieved, demonstrating the project's technical feasibility and alignment with Industry 4.0 goals.

The dual-adapter architecture significantly improved packet reliability and switching latency, while the GUI ensured transparent system monitoring. Additionally, modular hardware design and ethical considerations reinforced the project's relevance in practical industrial applications.

10.2 Future Work

While this project is currently demonstrates an intelligent network switching mechanism between Wi-Fi & Lo-Ra for real-time industrial monitoring, there are several modification and upgradation which can increase the projects scalability, effectiveness and make the system more robust.

1. Integration of Machine Learning for Resource Identification & Monitoring.

Addition of camera setup and Image Processing technique in this current project can make a resource monitor from the project. By these industrial entities will be able to keep track of their raw materials. Further decision making capabilities can be also added by the integration of Machine learning.

2. Multiple Robot Communication & Coordination

At this stage the project is based upon single robot and its network transmission & switching. In future prospect this can be implemented in multiple robot environment. That will open a door for innovation and research.

3. Finding Network Blind Spots in Broaden Industrial Environment & Highways.

In the broaden industrial areas and long highways there are ample of network blind spots which remain undiscovered. By integrating this rover, we can make sure of finding those and work on network fixation in those discovered blind spots.

4. Extended Range Testing in Real-World Environments

Current prototype was designed under stimulated indoor conditions. Future test runs should be implemented in real life cases with extended and more complex range where there would be scenarios like interference conditions, dynamic obstacles and environmental noise.

5. Power Optimization and Secondary Energy Harvesting

As the project tends to be implemented in longer deployment times, integrating power-efficient strategies and exploring solar or RF energy, which can make the system enable of renewable energy. Thus, the system can be more autonomous and sustainable.

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Chapter 11: Identification of Complex Engineering Problems and Activities.

Attributes of Complex Engineering Problems (EP)

Table 11.1: Attributes of Complex Engineering Problems

	Attributes	Put tick (√) as appropriate
P1	Depth of knowledge required	√
P2	Range of conflicting requirements	
P3	Depth of analysis required	√
P4	Familiarity of issues	√
P5	Extent of applicable codes	√
P6	Extent of stakeholder involvement and needs	√
P7	Interdependence	

As per the requirements our project follows 5 different complex engineering attributes. However, every attribute will not be applicable to our projects. The major ones which will be appropriate as per the system are shown by giving a tick mark on the table. The justification for following those attributes are as follows:

- **P1 (Depth of knowledge required):** For developing the system the first and the most important requirement is the depth of knowledge. Without knowing the problem and without knowing how to solve it, we will not be able to develop the system finely. The attribute is applicable for our project as we have deeply analyzed the problem first and then through literature review and studying the related works and we have developed the plan or the methodology to develop the system to solve the problem.

- **P3 (Depth of analysis required):** This feature of the depth of analysis is also present in our project. To monitor the network systems and design GUI, we must examine every aspect of it, which will eventually lead us to develop the system. In order to do network switching and bandwidth Optimization. Again, we must have an extensive analytical understanding in this area.

- **P4 (Familiarity of issues):** In this project many problems are unfamiliar but we are familiar with the solving criteria of this issue. Based on our acquired knowledge we will be able to solve these unfamiliar problems. Like if we want to develop the network monitoring system, what method will be the best method for network switching and bandwidth Optimization
  Thus our project follows the attribute of familiarity with issues as well.

- **P5 (Extent of applicable codes):** Our project follows the attribute of the extent of applicable codes. Just as, while developing the system there will be so many aspects and regulations that we need to consider. We have briefly explained the codes that we need to follow in table 5.

- **P6 (Extent of stakeholder involvement and needs):** As per our objectives we want to make the system industrially available . Now to serve this purpose we will contact the relevant companies and firms who work on developing network monitoring technological systems. So that the system can be manufactured industrially and as per their needs and requirements the changes will take place. Thus it qualifies the attribute of having stakeholder involvement in the project.

Attributes of Complex Engineering Activities (EA)

Table 11.2: Attributes of complex engineering activities

	Attributes	**Put tick (√) as appropriate**
A1	Range of resource	√
A2	Level of interaction	√
A3	Innovation	
A4	Consequences for society and the environment	
A5	Familiarity	√

While executing the system plans we are going to follow four different complex engineering activities. The reasons for following these EAs are as follows:

A1: Range of resources- Our project involves the source of diverse resources such as hardware, software materials, data & information, money, system based technologies. Thus our project follows these engineering activities.

A2: Level of interactions- This project follows this activity as well. While working on this project we need to maintain different levels of interactions with different people. Such as interactions with the collaborative partner, the industry and equipment owners, people related to data management, stakeholders, and investors.

A5: Familiarity- Our project requires the implementation of new principles we haven't encountered before. Such as implementing various communication aware algorithms to train our system to detect network contention which are unfamiliar to us.

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FYDP (P) Spring 2025 Summary of Team Log Book/ Journal

Group 09

Intelligent Robot Communication System for Network Switching in Indoor Industrial Environments

Table 12: Log book

	Final Year Design Project (D) Fall 2024		
Student Details	**NAME & ID**	**EMAIL ADDRESS**	**PHONE**
Member 1	Abdul Mukit 19121096	abdul.mukit@g.bracu.ac.bd	01612257575
Member 2	Mahira Tahseen 20121029	mahira.tahseen@g.bracu.ac.bd	017121341600
Member 3	Md.Omar Hossain Khan 20121079	omar.hossain.khan@g.bracu.ac.bd	01846194947
ATC Details:			
ATC 9			
Chair	Dr. Rony Kumer Saha	rony.saha@bracu.ac.bd	
Member 1	Bristy Das	bristy.das@bracu.ac.bd	
Member 2	Md. Muhiul Islam Muhiuddun	muhiul.islam@bracu.ac.bd	

<table>
<tr><th></th><th>Date/Time
/
Place</th><th>Attendee</th><th>Summary of Meeting Minutes</th><th>Responsible</th><th>Comment by ATC</th></tr>
<tr><td></td><td colspan="5">Week 1</td></tr>
<tr><td></td><td>12.02.2025
12:30 PM

Meeting with ATC panel members at 4E06</td><td>1. Mukit
2. Mahira
3. Omar</td><td>Discussing the overall work plan for FYDP C</td><td></td><td></td></tr>
<tr><td></td><td>14.02.2025
10:00 PM

Group Members Discussion via Online</td><td>1. Mukit
2. Mahira
3. Omar</td><td>Discussion on the necessary components for the project

1. Individually research which components to order/purchase, and component specifications based on project objectives.</td><td>Task 1:
Mahira, Mukit, Omar</td><td rowspan="2"></td></tr>
<tr><td></td><td colspan="3"></td><td>Task 1:
Completed.</td></tr>
<tr><td colspan="6">Week 2</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">17.02.2025
10:00 PM

Group Members Discussion via Online</td><td rowspan="2">1. Mukit
2. Mahira
3. Omar (absent)</td><td rowspan="2">Further discussion of the necessary components for the project

1. Planning on the fundamental structure of the Rover

2. Ordering/Purchasing the components of the rover</td><td>Task 1: Mukit,
Task 2: Mahira, Omar</td><td rowspan="2"></td></tr>
<tr><td>Task 1: Completed.
Task 2: Completed.</td></tr>
</table>

	19.02.2025 12:30 PM Meeting with ATC panel members at 4E06	1.Md. Muhiul Islam Muhiuddun 2. Bristy Das 3. Mukit 4. Mahira 5. Omar	Discussion on fulfilling objectives, the basic structure of the rover 1. Work on the hardware part of the line following rover 2. Work on the GUI for the rover 3. Order/Purchase more components if required.	Task 1: Mukit Task 2: Mahira Task 3: Omar	Present the ongoing work at the next meeting
				Task 1: **Partially Completed.** Task 2: **Partially Completed.**	
	21.02.2025 10:00 PM Group Members Discussion via Online	1. Mukit 2. Mahira 3. Omar (Absent)	Discussing progress and problems regarding the assigned tasks 1. Discussion on how to make the rover more stable, considering different industrial environments 2. Continue working on the GUI	Task 1: Mukit Task 2: Mahira	
				Task 1: **Partially Completed.** Task 2: **Partially Completed.**	
	Week 3				

	26.02.2025 12:30 PM Meeting with ATC panel members at 4E06	1.Md. Muhiul Islam Muhiuddun 2. Bristy Das 3. Mukit 4. Mahira 5. Omar	Show the overall progress of the given tasks 1. Work on the next steps, working with sensor data and wireless communication 2. Work on the integration of sensor data with the GUI 3. Start working on the report and slides for the progress presentation	Task 1: Mahira Task 2: Mukit Task 3: Omar	Work further to fulfill the objectives of the project
				Task 1: **Partially Completed.** Task 2: **Partially Completed.** Task 3: **Partially Completed.**	
	Week 4				
	05.03.2025 12:30 PM Meeting with ATC panel members at 4E06	1.Md. Muhiul Islam Muhiuddun 2. Bristy Das 3. Mukit 4. Mahira 5. Omar	Show the overall progress of the given tasks 1. Continue working with sensor data and wireless communication 2. Continue working on the integration of sensor data with the GUI 3. Work on the project report and slides	Task 1: Mukit Task 2: Mahira Task 3: Omar	
				Task 1: **In Progress.** Task 2: **In Progress.** Task 3: **In Progress.**	

	07.03.2025 11:00 PM Group Members Discussion via Online	1. Mukit 2. Mahira 3. Omar (absent)	Discussing progress and problems regarding the assigned tasks 1. Test the line following rover, integrating the GUI	Task 1: Mukit, Mahira	
				Task 1: **In Progress.**	
	Week 5				
	12.03.2025 12:30 PM Meeting with ATC panel members at 4E06	1.Md. Muhiul Islam Muhiuddun 2. Bristy Das 3. Mahira 4. Mukit 5. Omar	Discussing progress and problems regarding the assigned tasks 1. Test the line following rover, integrating the GUI 2. Debugging the GUI	Task 1: Mukit, Mahira Task 2: Mukit, Mahira	
				Task 1: **Complete** Task 2: **Complete.**	
	Week 7, 8 (Mid-Week)				
	Week 9 (Eid Vacation)				
	Week 10				
	09.04.2025 12:30 PM Group Members	1. Mukit 2. Mahira 3. Omar	Discussion on problems regarding the integration of the rover, GUI, and wireless communication	Task 1: Mahira	

	Discussion				
	Week 11 (Progress Presentation)				
	16.04.2025 12:30 PM Meeting with ATC panel members	1. Rony Kumer Saha 2. Md. Muhiul Islam Muhiuddun 3. Brishty Das 4. Mahira 5. Mukit 6. Omar	Progress Presentation 1. Chapter 1 of Final Report	Task 1: Omar	Submit Chapter 1 of the Final Report
				Task 1: **In Progress**	
	Week 12				
	23.05.2025 12:30 PM Meeting with ATC panel members	1.Md. Muhiul Islam Muhiuddun 2. Mukit 3. Mahira 4. Omar	Presenting and discussing the overall progress 1. Testing and debugging 2. Work on the report	Task 1: Mukit, Mahira Task 2: Omar	
	Week 13				
	30.05.2025 12:30 PM Meeting with ATC panel members	1.Md. Muhiul Islam Muhiuddun 2. Mukit 3. Mahira	Presenting and discussing the overall progress 1. Testing and debugging	Task 1: Mukit, Mahira	

	Week 14				
	07.05.2025 12:30 PM Meeting with ATC panel members	1.Md. Muhiul Islam Muhiuddun 2. Mukit 3. Mahira 4. Omar	Presenting and discussing the overall progress 1. Testing and debugging 2. Work on the report	Task 1: Mukit, Mahira Task 2: Omar	
	Week 15				
	14.05.2025 12:30 PM Meeting with ATC panel members	1.Md. Muhiul Islam Muhiuddun 2. Mukit 3. Mahira	Presenting and discussing the overall progress 1. Testing and debugging	Task 1: Mukit, Mahira	
	15.05.2025 02:00 PM Auditorium	1. Mukit 2. Mahira 3. Omar	Project Showcasing		