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Faculty of Engineering & Information Technology

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Graduation Project 2

IoT-based Smart School Bus

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Disclaimer

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Abstract

The IoT-based smart school bus is a modern solution that integrates various technologies to ensure the safety and comfort of students during their commutes. With IoT sensors, and GPS tracking technologies, the bus can monitor temperature and air quality, among others. This allows for prompt detection of any issues that result in cost savings and timely arrival to school. Additionally, the use of RFID tags adds an extra layer of security for students, to ensure that only authorized students are allowed onto the bus. Moreover, the smart lighting system installed in the bus ensures that students can study or relax in a well-lit environment. The lighting turns on and off automatically based on the time of day and the amount of natural light available, creating a comfortable atmosphere for learning. The Wi-Fi hotspot on the bus also provides students with access to the internet, allowing them to be connected to their parents on their way to school or home. It is also equipped with sensors that monitor the level of carbon dioxide inside the bus to ensure that the air quality is safe for students and drivers. Finally, the system sends real-time location information and the estimated time of arrival to the parents of the next student's home.

Chapter 1: Introduction

1.1 Problem Statement

Nowadays, parents are increasingly protective of their children and have many fears and concerns about their children's safety, particularly in Palestine. Even if their children ride the school bus to school, they still require information such as location updates and student attendance to ensure that their children are in a safe environment and conditions. Traditional school buses in general may have issues with appropriate ventilation, lighting, and heating, at the same time, they lack advanced technologies and monitoring capabilities. Additionally, school administrators and officials require some level of supervision and tracking for their buses and drivers.

1.2 Objectives and scope of work

The primary goal of the smart school bus is to benefit parents, students, and school administration by allowing parents to track the location of the bus, the status of their child – whether at school or on the bus – and ensure that they are safe. School administrators can also track their buses using the map that is linked to each one. Students are directed to the correct bus and have a relaxing experience while on the bus.

1.3 Report Organization

Second Chapter: Constraints and Earlier course work

- Describes the constraints we faced and the university courses that help us while working on the smart school bus.

Third Chapter: Literature Review

- Discusses the main features of other similar projects and the difference between them and the smart school bus project.

Fourth Chapter: Methodology

- Describes the process of working on the project starting from preparing for the features, choosing the main components and the communication between them, and the construction of a mobile application for tracking and data collection.

Fifth Chapter: Results

- Discusses the results and features the smart school bus has.

Sixth Chapter: Conclusion

- Give a small summary of the main feature of the project and the basic concepts used.

Chapter 2: Constraints and Earlier Course Work

2.1 Constraints

- The use of the GPS module requires working in an open area in order to enable it to get the signal from satellites, which makes things a bit hard in the phase of development.
- The sim800L GSM module requires sustainable power and current source in order to operate properly and correctly (4v / 2A), and the use of batteries is impractical for this case.

2.2 Earlier Course Work

- **Electronics I & II courses:** Electronics courses are very essential, and the knowledge gained from them helped in dealing with electronic circuits in the projects.
- **Microcontrollers course and Lab:** are of the most important courses, as the whole project depends on working with microcontrollers and interfacing other components with them.

- **Critical Thinking and research methodology:** The critical thinking course helps us to be aware of the research principles, methodologies, and scientific writing.

Chapter 3: Literature Review

The idea of this project was inspired by multiple real-world projects, in which they have similar used technologies like RFID, GPS and GSM, and here are some of them:

- **FMS Tech. School Bus:** It is a project used in the United Arab Emirates (UAE) to provide smart school bus solutions. It employs RFID technology to identify pupils, GPS position tracking, and a specialized mobile app for both parents and school administrators to get student and bus updates.
- **Wireless Links school bus:** It is a project implemented in the United Kingdom to deliver an RFID school bus GPS tracking system and software to parents by utilizing a bus position tracking system, RFID school ID tracker and tracking software.
- "Design and Implementation of a Smart School Bus System Using IoT and Cloud Computing." a paper by Liu, H., et al. International Journal of Distributed Sensor Networks. This research introduced a smart school bus system that integrated IoT sensors, GPS tracking, and cloud computing. The system monitored environmental conditions, student presence through RFID tags, and provided real-time notifications to parents and school officials.

What makes this project stand out from other examples?

While previous projects have explored aspects of designing and implementing smart school bus systems, this project stands out in several ways, firstly, it combines several technologies, such as IoT sensors, GPS tracking, RFID tags, smart lighting systems and Wi-Fi hotspots. Furthermore, the use of a carbon dioxide sensor inside the bus highlights a specific focus on ensuring safe and healthy air quality for both students and drivers. This feature sets this project apart by addressing an important aspect of student well-being during transportation. Finally, The smart system's ability to instantly contact students' parents when the bus is near the house or is arriving at their house while delivering real-time

information about the bus's location and driver reduces latencies that might occur and results in on-time arrival to school.

Chapter 4: Methodology

4.1 Requirements Analysis:

An extensive analysis was performed when building the smart school bus system to identify the main characteristics and needs. The major goal was to ensure students' safety and well-being throughout their transportation route, taking into consideration many elements that might contribute to the system's overall effectiveness.

Student safety was one of the most important factors. It was critical to implement techniques that would ensure a safe environment for students on their daily commute to school. This involved applying advanced safety measures, such as emergency alerts to school administrators and parents, which could alert them promptly in case of any unexpected events. In addition to GPS tracking in which bus location is sent to parents and school along the journey.

4.2 System Design:

The system is composed of two parts: local tracking and bus tracking over the internet, which serves both parents and school administration. Temperature, air quality, and lighting are all monitored locally. The second part involves GPS location tracking in which the bus's location is sent over the internet. Additionally, notifications are sent to the parents when the bus is nearby via GSM as SMS messages.

4.3 Hardware and Software Implementation:

4.3.1 Hardware

The system is composed of multiple hardware components and microcontrollers that collaborate together to produce the smart school bus system. And they are described below:

1. **Arduino UNO:** It is the microcontroller that is used to implement local monitoring of the bus, some of the sensors are connected to it in order to track temperature, air quality and lighting, and provide a comfortable environment for students. Based on the sensors readings, Arduino UNO takes actions to turn the lights on/off, turns on the AC, etc.



Figure 4.1: Arduino UNO board

2. **ESP32-WROOM-DA WiFi module:** It is the microcontroller that communicates with a centralized server and sends and receives data about GPS location and students attendance.

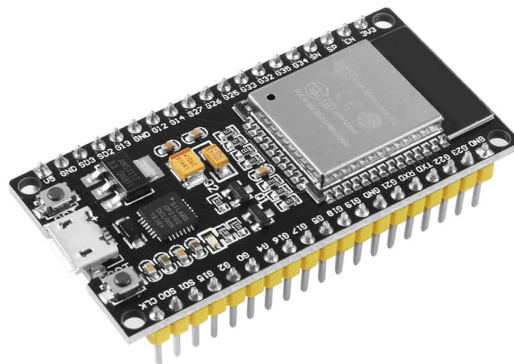


Figure 4.2: ESP32-WROOM-DA board

3. **RC522 RFID reader:** The RFID reader is connected to the esp32, it reads the tag that is held by the student to make sure that he/she belongs to this bus, this is done by sending a request to the server to get the student's details.



Figure 4.3: ESP32-WROOM-DA board

- 4. GY-NEO6M GPS module:** The GPS module is connected to the esp32, it finds the location of the bus, and then it is sent to the server in order to enable parents and school officials to track its location using the mobile application associated with the bus.

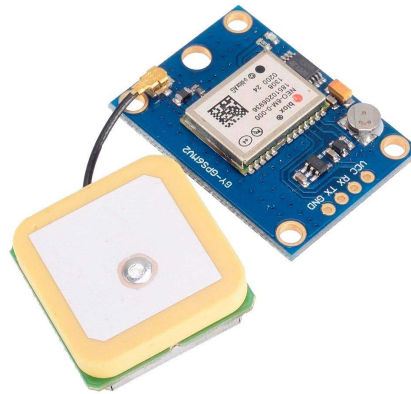


Figure 4.4: GY-NEO6M GPS module

- 5. DHT11 temperature sensor:** It is linked to the Arduino board and monitors the temperature and humidity within the bus; when the temperature rises, the Fan activates to lower it.

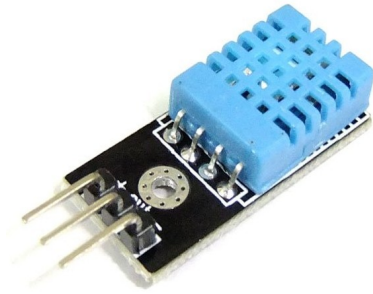


Figure 4.5: DHT11 temperature & humidity sensor

6. **LDR sensor:** It senses and monitors the amount of light in the bus, and if there is insufficient lighting, the bus's lights turn on.

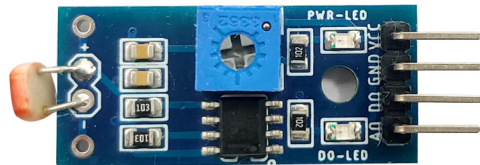


Figure 4.6: LDR sensor

7. **Small Fan:** It turns on whenever the temperature goes below 25 °C



Figure 4.7: Small fan

8. **LED stripe:** It turns on when the lighting inside the bus becomes insufficient.



Figure 4.8: LED stripe

- 9. LCD screen:** It is used to display student's information on it when he/she scans their card to enter or leave the bus.



Figure 4.9: LCD display

- 10. SIM800L GSM module:** it is used to send a message to parents when the bus is coming next to their house.

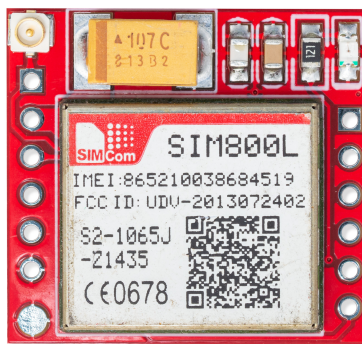


Figure 4.10: SIM800L GSM module

11. Gas Sensor MQ6: it is used to detect the concentration of CO₂ gas inside the bus.

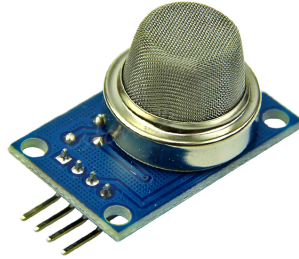


Figure 4.11: MQ6 gas sensor

12. Two Servo motors: they are used to control the ventilation port on the top of the bus.



Figure 4.12: Servo motor

13. DC-DC buck converter: It is used to convert 12v into 4v to supply the sim800L module.

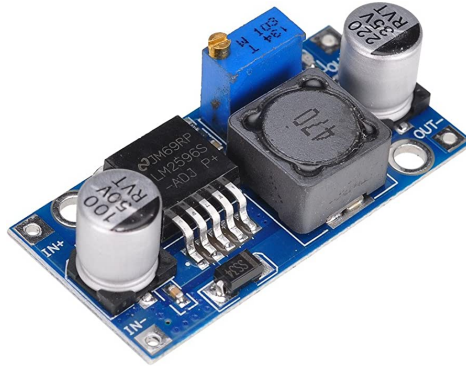


Figure 4.13: DC-DC buck converter

14. Ultrasonic sensor: It is used to measure the distance the bus and nearby objects from its back side.



Figure 4.14: Ultrasonic sensor

15. Two 5V Single-channel relays: they are used as electronic switches for the fan and the LED stripe to turn them on or off.

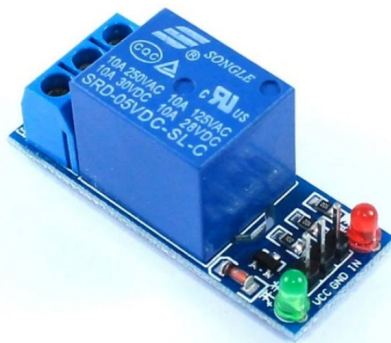


Figure 4.15: 5V single-channel relay

4.3.2 Software

In order to make tracking easier for both parents and school, a mobile application is implemented to show students' and bus information like GPS location, student's status, drivers' info, etc.

It has a login page, and both parents and school officials can login, and each of them has different pages and tracking features.

Parents can view the bus's location through the map provided in the app, as the figures below shows:

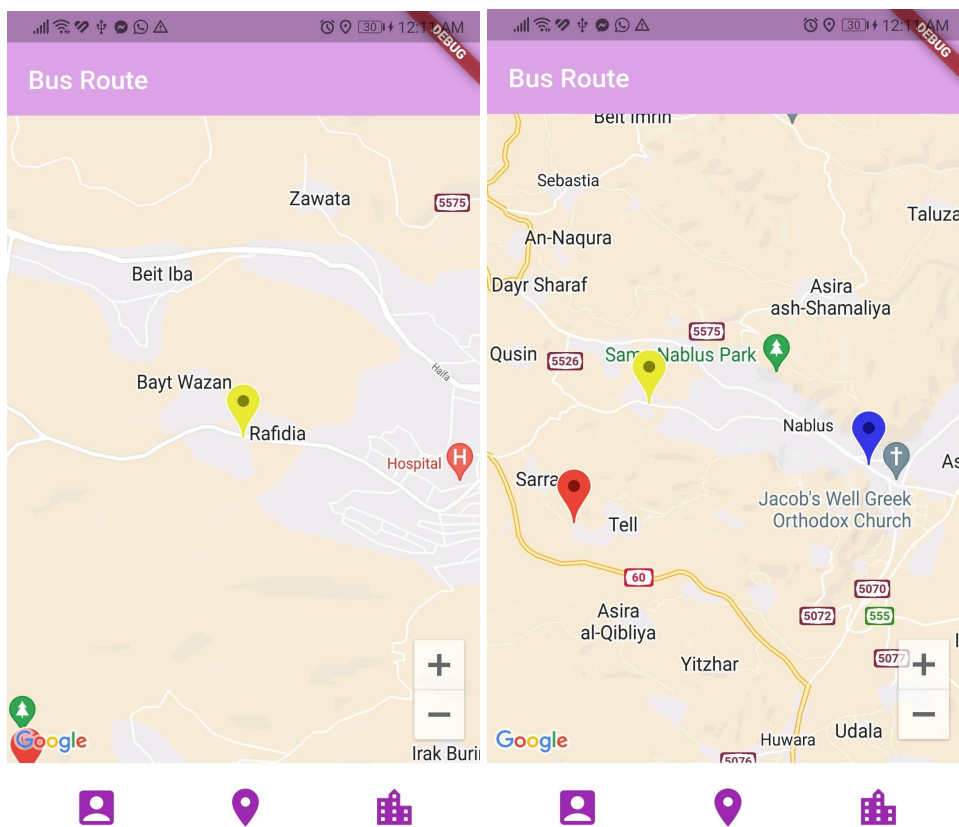


Figure 4.15: Bus location tracking on map

The map shows the current location of the bus as well as the parent and school locations.

And they have the option to add their phone number and address in order to be stored in the database:

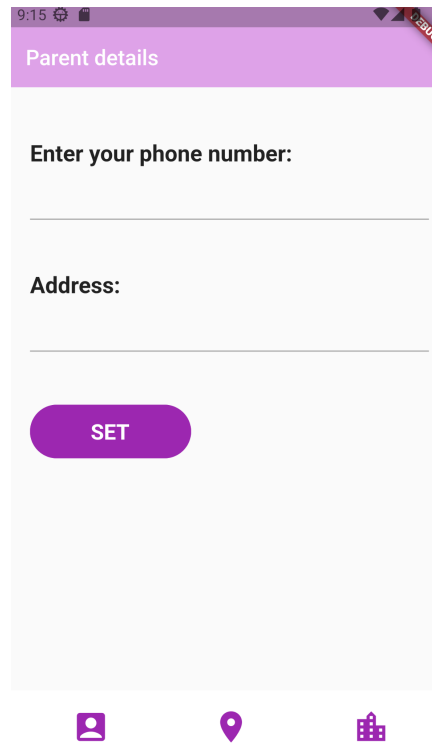


Figure 4.16: Parent's details

4.3.3 Implementation

1. ESP32 microcontroller:

- **Student authorization:** when a student enters the bus, he/she scans their card in order to enable the bus's administrator to make sure that they belong to this bus, this is done by sending an http request over WiFi to the server where all students' details are stored, and then if the student belongs to this bus, the LCD screen displays the student's name and a welcome message, and the same time, changes the status of the student whether they are inside the bus, the school or at home, otherwise the LCD displays the bus number that the student belongs to. After that an SMS message is sent to the next student's parents that contains real-time location information, in addition to the estimated driving time to arrive.

- **Bus location tracking:** the location of the bus is taken and found by the GPS module connected to ESP32 board, it continuously finds the location and sends it to the server, in order to be tracked and monitored by parents.

2. Arduino Uno:

- **Temperature monitoring:** the temperature sensor is connected to the arduino board in order to monitor the temperature inside the bus, especially in summer, when it goes higher than 25 °C, the fan turns on to lower the temperature.
 - **Lighting monitoring:** the LDR sensor is connected to the arduino board to measure the amount of light inside the bus, when it becomes darker, the arduino uno turns on the lights, so it controls the lighting based on the time of the day.
 - **Air quality monitoring:** the gas sensor is connected to the arduino board, it measures the concentration of carbon dioxide gas in the air, when it increases, the ventilation port opens with the help of the servo motors.
 - **Students detection:** the ultrasonic sensor is used and placed on the back side of the bus in order to detect students or people that may not be visible to the driver.
3. **Mobile App:** the mobile application was built using flutter framework, the server was written using Node Js framework and the database used is MySQL. Google Maps API was used for the map, for location tracking purposes.

Chapter 5: Results

The smart school bus system is a unique system because:

- It Improved the environment inside the bus through the air quality, lights and heating control.
- It helped parents to track their children and make sure that they are safe.
- It reduces delays as it notifies the parents that the bus is nearby.

Chapter 6: Conclusion and Future work

6.1 Conclusion

The smart school bus system has effectively used a variety of smart technologies to enhance the safety, efficiency, and overall experience of school transportation. The integration of GPS tracking enabled parents to track their children.

Furthermore, the use of RFID technology allows only authorized students to board the bus, reducing any form of chaos. Finally the use of GSM technology makes instant notifications with real-time location information to parents reduces latencies that might happen.

6.2 Future work

In order to take care of students inside the bus on the physical side, we can give students smart watches that will be able to measure their temperature and other health issues in order to make parents and school aware of the symptoms any one might have and take quick actions based on that.