Final Year Design Project
Final Report
[EEE 400C or ECE 402C]

Project Title

Implementing Smart Bus Stand to reduce local transportation risks for passengers in Dhaka city.

By

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Chapter 1: Introduction

1.1 Introduction

The citizens of Dhaka city mostly depend on public transportations to reach a certain destination. Maximum citizen prefers public bus because it is mostly available, provides inexpensive journey at long distances and half fee services for students. However, citizens are willing to risk their lives, as most of them are careless about unknown consequences when they get into the running bus. Furthermore, most local bus have a bad reputation while onboarding new passengers as they hardly keep the bus static. Besides, these circumstances when a public bus stop completely for new passengers it stops in the middle of the road causing driving discomfort for many citizens. Therefore, it is high time; an optimization must take place to solve these problems and provide comfort for citizens.

1.1.1 Problem Statement

Dhaka city is the capital of Bangladesh, consisting of overpopulation causing citizens to face massive difficulty in transport. As a result, it creates a huge crowd at bus stops. Transportation in public buses is riskier than any other transportation vehicle. In Dhaka city, there lies no special bus stand or stop so that people can enter a local bus with comfort rather than the signed boards, which are present, are most of the time ignored. Thus in order to reduce such risks for the citizens of Dhaka city, a smart bus stand system is mandatory.

1.1.2 Background Study

Population is increasing day by day and to tackle this huge population, our transportation system should be modernized. A smart bus stop can be proposed as a solution to this problem. Using various sensors, we can track data related to buses and the surrounding environment of the bus stop. These data can be sent to a mobile app through a web server to keep the passengers updated [1]. To locate the buses, technologies like Bluetooth, GPS or RFID can be used [2]. In addition to improving bus stops, we should also improve our ticketing system. In the current ticketing system, there are problems such as long waiting times, inability to refund ticket purchases, wastage of paper, lack of proper seat allocation, etc. The solutions to these problems are app-based ticket purchasing, OTP-based ticket delivery [3], easy refund process, and seat selection, which are sure to improve the ticking experience remarkably [4]. After ensuring a safe and easy ticketing system, a smart bus tracking system is necessary. A smart bus tracking system can be implemented using QR codes [4] to access bus stop coordinates. The given QR code can be obtained from respective bus stops so that passengers can scan them with their smartphones to locate their interested bus on a map with an approximate reaching time. QR code implementation is efficient as it is cost-effective and [5] used regularly. Modern bus tracking systems and monitoring can be done in several ways. GPS and RFID are most familiar. GPS is widely used around the world but it

consumes a lot of power. On the other hand, RFID is very cost-efficient and less power consuming [7]. So, RFID can be a perfect solution for a bus tracking system that allows commuters to know the exact location of the bus using a web server [8].

1.1.3 Literature Gap

For an efficient entry system for the smart bus a dedicated queue management system is compulsory. Thus to keep a convenient system an ESP32 CAM module is used with a FTDI programmer to upload the code and using Q – CAM function images are captured and send through build in Wi-Fi to users to alert about their queue number [9]. Using ESP32 CAM enables to perform multiple scanning processes and one of them using QR codes to open a bank locker to enable a secured transaction [10]. The security system may consist of multiple stages for verification such as verifying username, password, fingerprint and one time password by using GSM module [11]. Then to enable a comfort journey vehicle tracking system is implemented using GPS and GSM module with a microcontroller to send the latitude and longitude data [12]. However, such data must transmitted to a cloud-based platform called Think Speak to store the given coordinates. For example storing medical data of a patient using Wi-Fi and Think Speak cloud-based platform [13]. Using wireless monitoring system critical patients such as disabled can receive maximum support [14]. Now, to provide maximum functions in a convenient manner an app based method is the way to go which not only include availability and estimated arrival time but also alert passengers to identify crowed locations [15]. Moreover, only valid entry is allowed using tickets to provide a smart transportation system [16].

1.1.4 Relevance to current and future Industry

As Bangladesh is a developing country, so the absence of a smart bus system is normal. However, recently Dhaka Nagar Paribahan is going to launch an E–Ticketing system, which will travel from Ghatarchaor-Mohammadpur-Gulishan-Motijheel-Signboard-Kachpur Bridge daily. It has been initiated by two mayors and at an opening ceremony Minister of Road Transport and Bridges Obaidul Quader joined virtually. Each staff of Dhaka Nagar Paribahan will have their own dedicated uniform with individual ID card. It is believed that this green colored bus is an experimental implementation and it everything goes well then this will reduce traffic problems on roads [17]. Since this is a test subject so, there might is some unknown consequences. The future industry is still uncertain as this has been launched recently so, after some test cases and public feedback then the system can be improved or developed according to customer satisfaction.

1.2 Objectives, Requirements, Specification and constraint

1.2.1. Objectives

- To reduce local transportation risks for passengers in Dhaka city.
- To design and implement a smart bus stand system to reduce passenger overcrowd.
- Implementing a serial-wise ticket vending system with convenient user interfacing to ensure passengers follow the queue.
- Installing a monitoring system to alert the public about the latest updates of incoming and outgoing buses.
- To design a convenient user interface that must be user-friendly and less complicated.

1.2.2 Functional and Nonfunctional Requirements

Functional Requirements:

- Implementing an organized ticket vending system.
- Only allowing authorized entry from respective bus stops.
- Monitoring live bus locations using GPS.
- Continuous electric supply & internet connectivity.
- Maintaining a hassle-free bus entry system by maintaining a controlled queue.

Non-Functional Requirements:

- To implement the entire system using common PVC/plywood to establish the main structure.
- To establish the system in such a way that it is easy to notice in public roads yet does not negatively affect the attractiveness of the environment.

1.2.2 Specifications

System	Sub-System	Requirements	Components	Specifications	Comment
Ticket Vending System	Ticket Vending Machine	Central Processing Unit for BUS Stand	Raspberry Pi 4	• Broadcom BCM2711, Quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz Processor • 2 GB Ram • 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE • OpenGL ES 3.0 graphics	Used in the Bus Stand as a backbone for ticket machines and live GPS Tracker.

		Display	7 inch HDMI Touchscreen LCD	• 7-inch Screen Size • 1024x600 IPS Display • HDMI Input	Used as a display for ticket machines for bus selection and payment options.
		Ticket Printing	HP DeskJet Printer	• Printing Resolution 1200x1200 DPI	Used to print the QR code-based ticket.
Bus Monitoring System	**Connectivity System**	**Internet Connectivity**	**SIM800L Mini GPRS GSM Module**	TTL serial port for serial port	Used in Bus to have internet connectivity and send GPS data to the bus stand.
	Bus Positioning System	**Bus Tracker**	**U-Blox NEO-6M GPS Module**	A complete GPS module with an active antenna integrated, and a built-in EEPROM to save configuration parameter data.	Used in BUS to send GPS data
	Ticket Scanning System	**Ticket Scanner**	**ESP32-CAM WiFi + Bluetooth Camera Module Development Board ESP32 With Camera Module OV2640**	• Ultra-small 802.11b/g/n Wi-Fi BT/BLE SoC module • Low-power dual-core 32-bit CPU for application processors • Up to 240MHz, up to 600 DMIPS • Supports interfaces such as UART/SPI/I2C/PWM/ADC/ DAC • Support OV2640 and OV7670 cameras with built-in flash • Support Smart Config distribution network	Used in Bus to scan and verify the ticket.

		Central Processing Unit for BUS	**Arduino UNO R3**	• The Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. • It has a resistor pulling the 8U2 HWB line to the ground. • Flash Memory 32 KB (ATmega328) of which 0.5 KB used by the bootloader • SRAM 2 KB (ATmega328) • EEPROM 1 KB • (ATmega328) • Clock Speed 16 MHz	Used in the bus as a backbone for ticket scanners.
	Passenger Tracking System	**Tracking Current number of passenger**	**5mW Adjustable Laser Dot Diode Module x2**	• Output Power: 2-5mW • Wavelength: 650nm • Working Voltage: 3v - 5v • Laser Shape: Dot • Working temperature: -10 C-40 C	Installed on the bus door to stop unauthorized entry.
			Optical Sensitive Resistance Light Detection Photosensitive LDR Sensor Module x2	• Photosensitive resistance module's most sensitive to ambient light commonly used to detect the environment around them the brightness of the light, or MCU trigger relay module, etc.	
	Bus Entry Authorization System	**Bus Door**	SG90 9G Micro Servo Motor	• Operating Speed: 0.12sec/60 degree(4.8V)~0.1sec/60 degree(6.0V) • Torque: 1.6kg/cm(4.8V) • Servo Type: Analog Servo Brand • Band Width: 5 usec	Used to rotate the gate lever in the bus.

1.2.3 Technical and Non-technical consideration and constraint in design process

Technical Considerations:

- Convenient user interface for accessibility.
- Components availability.
- Swappable options.
- Easy components interfacing.
- Cost effective.
- Easy maintenance.

Non-technical Considerations:

- Advertising.
- Installing E-Transaction policies from Bangladesh Bank.
- Lawyer to ensure legal approval.

Constraints:

- Unauthorized entry.
- Complicated troubleshooting.
- Overvoltage protection.
- Continuous electric supply & internet connectivity.
- Space consumption restrictions on a public footpath.
- For best outcomes, some of the components are not budget-friendly.

1.2.4 Applicable compliance, standards, and codes

Required Standard	Standard Number	Definition	Comment/How does it affect our solution
Global System for Mobile Communications (GSM)	ETSI (3GPP TS 45.005)	The Global System for Mobile Communications (GSM) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks.	This standard is used to send the GPS data from the module to the server wirelessly.
Wireless Fidelity (Wi-Fi)	IEEE 802.11	Wireless Fidelity is a standard developed by IEEE 802.11, which tells the accuracy of the given signal in terms of range and quantity of data.	This technology is used in the bus stand to fetch the data containing GPS details from the server.
Global Positioning System (GPS)	WGS-84	GPS uses the World Geodetic System WGS-84 which is developed by the US Defense Department as a reference system for position and vector referencing.	It is used to get the real-time position of the bus using multiple GPS satellites.

Bangladesh Bank E-Transaction policies		E-commerce is common now a days for a better and comfortable living. However, all the payments and protocols are controlled from central bank to ensure a safe transaction.	It is used to maintain all the legal process of a correct transaction.

1.3 Systematic Overview/summary of the proposed project

The system will start with a Ticket Vending machine which will include a raspberry pi 4 mini computer, and a 7 inch HDMI Touchscreen LCD display in the bus stand (Figure 1). Users will be able to select their bus for the destination they want to travel (Figure 2). The live position feedback will be displayed on the selection page, and after that they will proceed to payment. After successful payment, a QR Code-based ticket will be printed and the code will also be sent to the server. The payment process will be completed through SSL Commerz such as BKash.

The second part of the system will be implemented at the bus entrance (Figure 3). A microcontroller (Arduino UNO R3) will be used as the CPU for the whole system in the bus. There will be a scanner (ESP-CAM) which will scan the QR Code-based ticket. Meanwhile, internet connectivity will be established with a SIM800L Mini GPRS GSM module, and through it, the controller will download all the available QR codes for the server and compare them with the scanned data. If the code matches, then the servo motor will be triggered to lift the bar (Figure 2). A counter will also be attached to the door to calculate the latest number of passengers on the bus so that later on the data will be sent to the server. The latest passenger number can be shown at the ticket vending machine, and depending on that number next tickets can be assigned. Finally, U-Blox NEO-6M GPS module will sense the current position of the bus and will give updated live locations to the server which will allow passengers to see the live locations from the bus stand.

Fig: The Bus Stand

Fig: Ticket Vending Machine

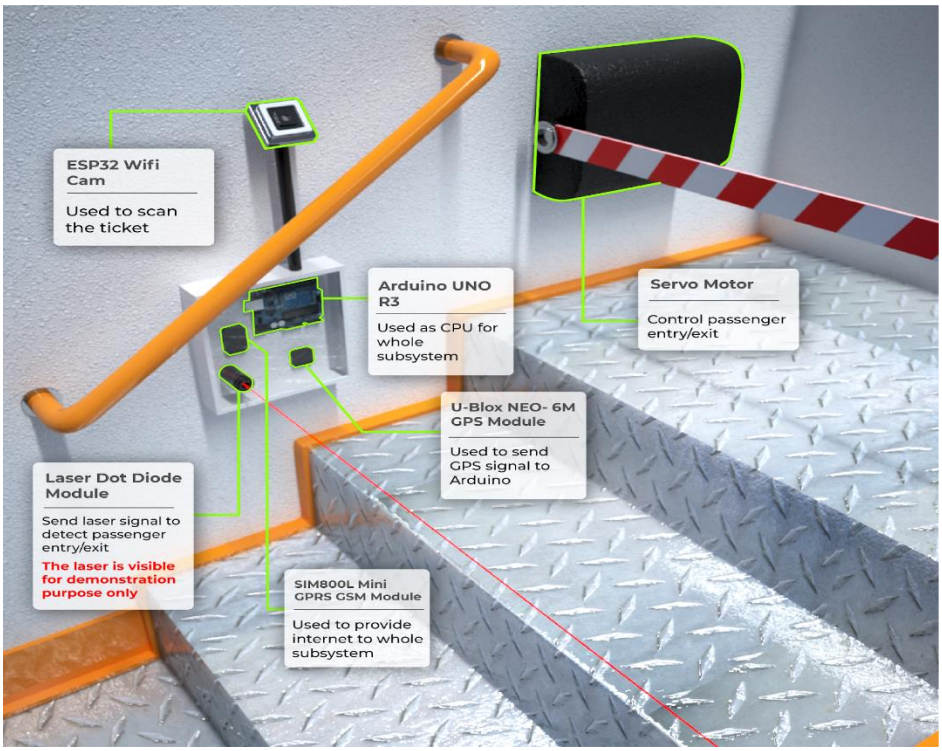


Fig: Bus Entry

1.4 Conclusion

Most of the citizens of Dhaka city depend on public transportation but it is unfortunate that they are bound to take high amount of risk while getting into the running bus. Thus, they lies no safety procedures to travel effectively. Furthermore, the sign boards present are hardly serves any purpose. Therefore, to solve such issue we are building a controlled embedded system, which will enable citizen to reach their destination without any risk. Using a ticket vending system with scanner, GPS coordinates, GSM connectivity, cloud platform and current passenger count we will be able to solve our problem.

Chapter 2: Project Design Approach

2.1 Introduction

According to our desired objective, requirements, and constraints, we have found a total of 7 designs. Each of the designs fulfills all necessary criteria. Each design will be explained in detail. Firstly, to fulfill the objective we need to make sure our design covers all of our goals. Secondly, to reach our goal we must see all the necessary requirements to solve our problem. Finally, we must ensure it follows all the restrictions or constraints to get an efficient solution. Thus, we will be able to fulfill all criteria.

2.2 Identify multiple design approach

- **Design 1:** Using GSM & GPS.
- **Design 2:** Using Raspberry Pi inside the bus instead of Arduino Uno.
- **Design 3:** OTP based system (One Time Password).
- **Design 4:** App-Based E-Ticketing System.
- **Design 5:** Using Tablet phones instead of using individual controllers.
- **Design 6:** Using Wi-Fi instead of GSM module.
- **Design 7:** Using RFID module instead of GSM module.

2.3 Describe multiple design approach

i) Design 1: Using GSM & GPS:

Objective: In this design, we can see that by using standard components we can reduce overcrowding, as we will have less delay. Using a QR code scanner, we will be able to maintain the queue. Thus, a convenient ticketing system is maintained, and since we are using modern technology so we can enable a convenient user interface. Finally, the live location of current buses is also possible.

Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two reliable processing units both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, printing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved.

Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public footpath. The design is cost-effective. However, to ensure continuous electric supply we can

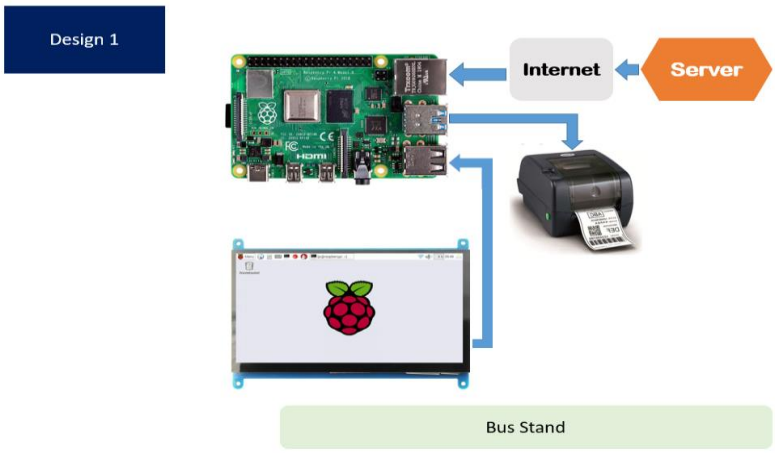
update our system in the future to run in battery mode during any load shedding and continuous internet connectivity is also ensured if the server runs stable.

Criteria Table for Design 1:

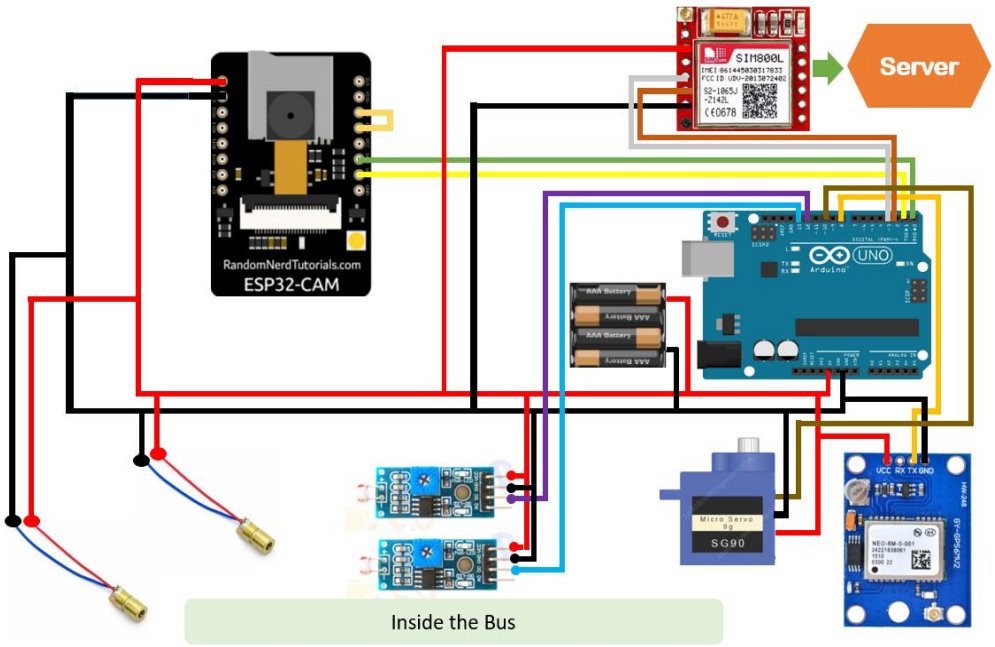
Objectives	Requirements	Constraints
✓	✓	✓

Design Process of Design 1:

At the Bus Stand:



Inside the Bus:



ii) Design 2: Using Raspberry Pi inside the bus instead of Arduino Uno:

Objective: In this design, we can see that by using standard components we can reduce overcrowding as we will have less delay. Using a QR code scanner we will be able to maintain the queue. Thus, a convenient ticketing system is maintained, and also since we are using modern technology so we can enable a convenient user interface. Finally, the live location of current buses is also possible. Similar to design 1.

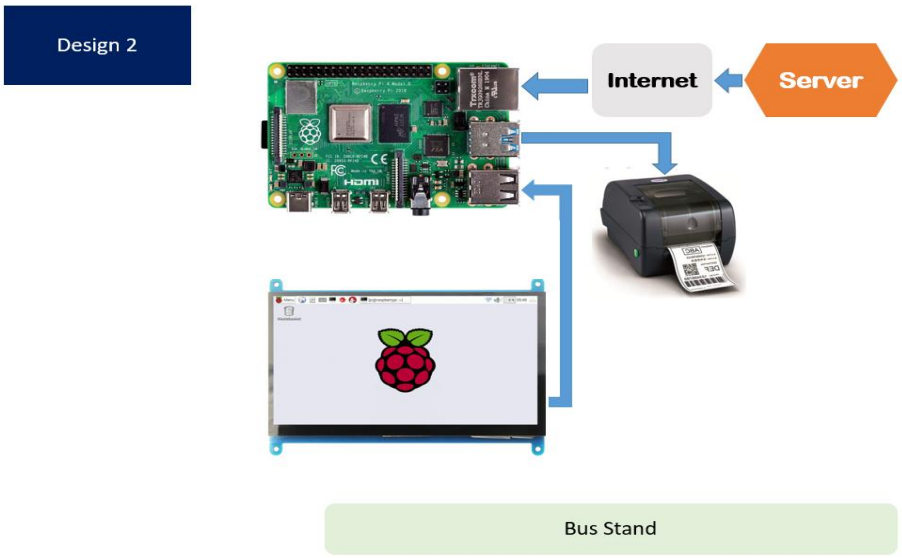
Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two powerful processing units both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, printing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved. Similar to design 1 but it has more processing power.

Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public footpath. The design is almost cost-effective. However, to ensure continuous electric supply we can update our system in the future to run in battery mode during any load shedding and continuous internet connectivity is also ensured if the server runs stable. Similar to design 1.

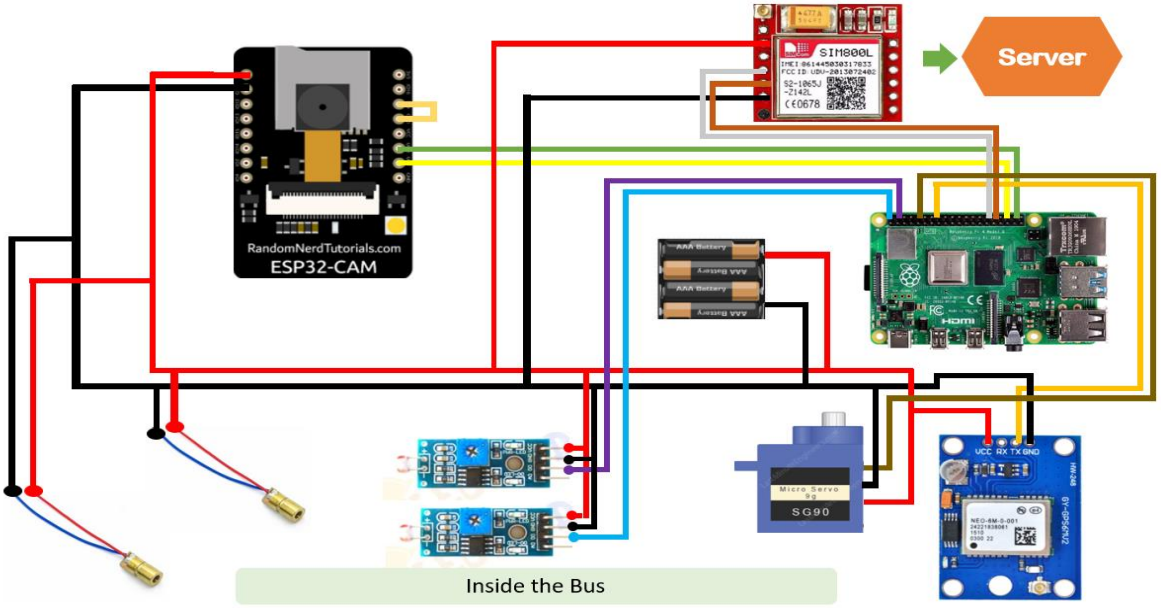
Criteria Table and Design Process for Design 2:

Objectives	Requirements	Constraints
✓	✓	Almost Fulfilled

At the Bus Stand:



Inside the Bus:



iii) Design 3: OTP based system (One Time Password):

Objective: In this design, we can see that by using standard components we can reduce overcrowding with less delay for a maximum case. Using an OTP-based system we will be able to maintain the queue. This system is almost equivalent to an ATM machine for transactions. Thus, a convenient ticketing system is maintained, and also since we are using modern technology so we can enable a convenient user interface. Finally, the live location of current buses is also possible. Similar to design 1 instead of a QR code a one-time password is generated.

Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two reliable processing units both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, printing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved. Similar to design 1.

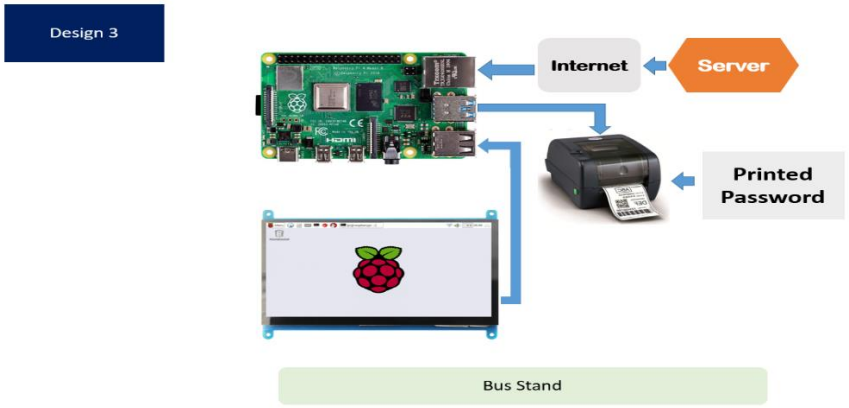
Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public footpath. The design is cost-effective. However, to ensure continuous electric supply we can update our system in the future to run in battery mode during any load shedding and continuous internet connectivity is also ensured if the server runs stable. Similar to design 1.

Criteria Table for Design 3:

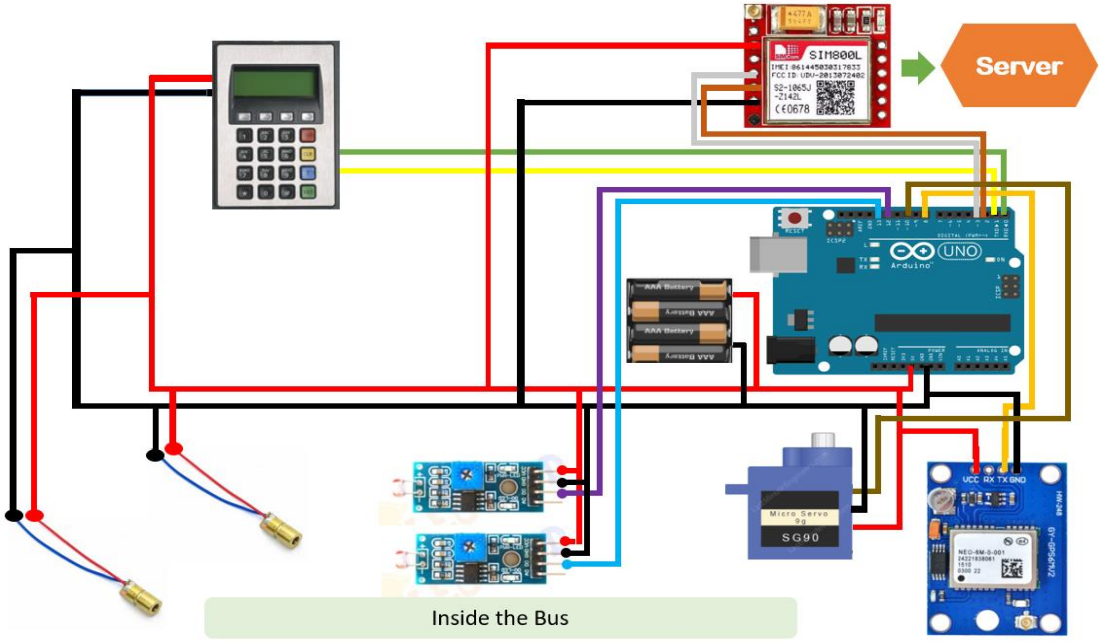
Objectives	Requirements	Constraints
✓	✓	✓

Design Process of Design 3:

At the Bus Stand:



Inside the Bus:



iv) Design 4: App-Based E-Ticketing System:

Objective: In this design, we can see that by using standard components we can reduce overcrowding as we will have less delay. Using a QR code scanner we will be able to maintain the queue. Thus, a convenient E-ticketing system is maintained, and also since we are using modern technology we can enable a convenient user interface. Finally, the live location of current buses is also possible. Similar to design 1.

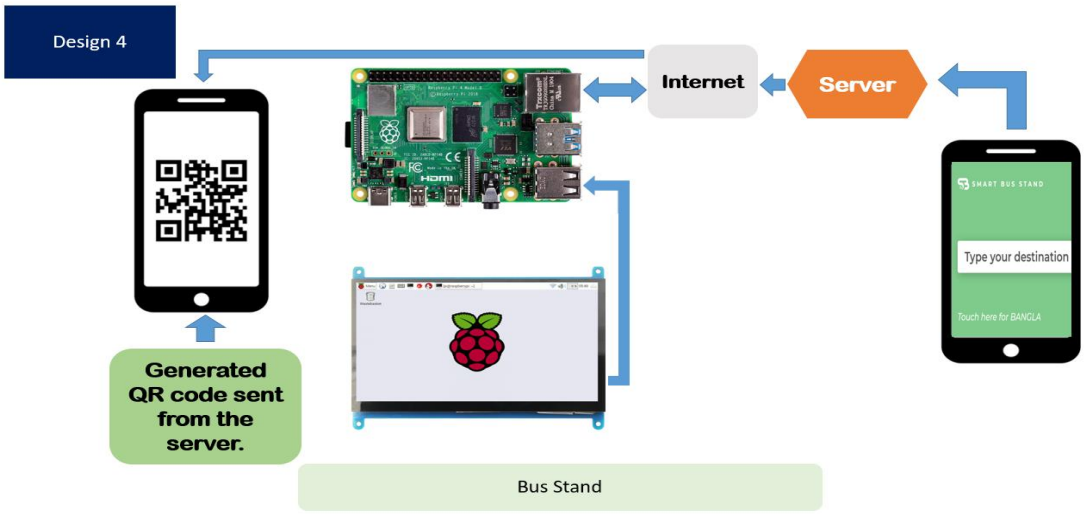
Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two reliable processing units both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved. Similar to design 1 but it only uses soft copies of tickets rather than hard copies. Thus we do not need to print tickets.

Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public footpath. The design is cost-effective. However, to ensure continuous electric supply we can update our system in the future to run in battery mode during any load shedding and continuous internet connectivity is also ensured if the server runs stable. Similar to previous designs.

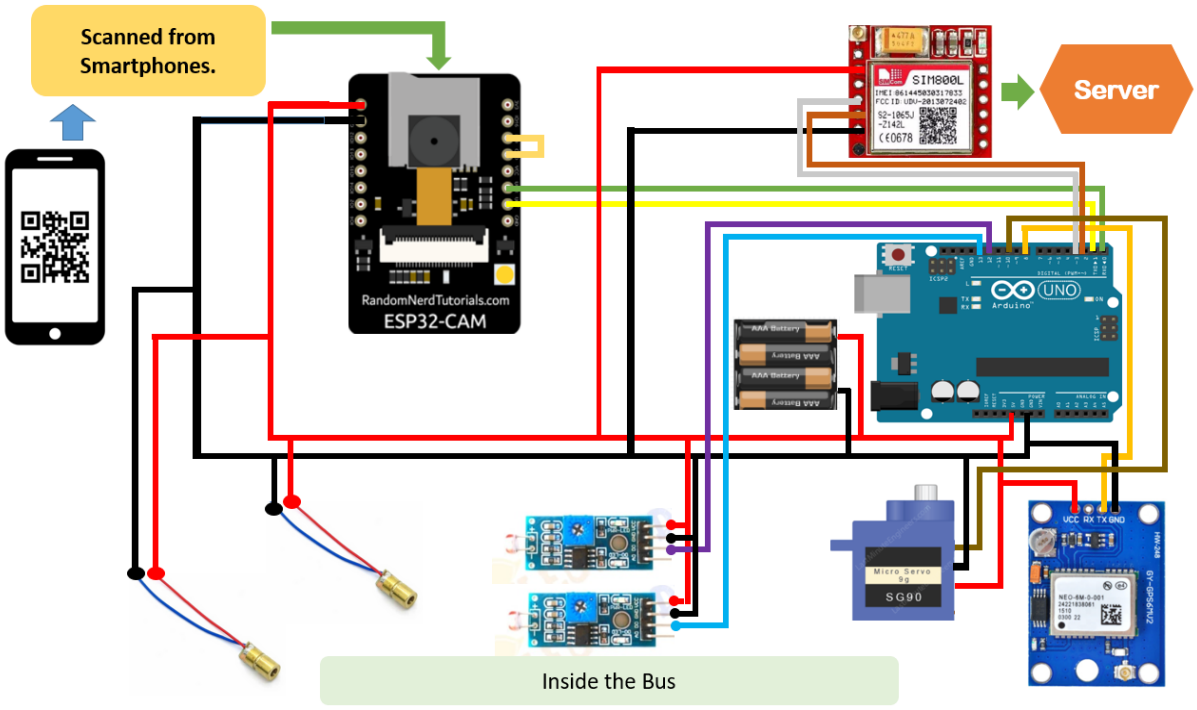
Criteria Table for Design 4 and Design Process:

Objectives	Requirements	Constraints
✓	✓	✓

At the Bus Stand:



Inside the Bus:



v) Design 5: Using Tablet phones instead of using individual controllers:

Objective: In this design, we can see that by using standard components we can reduce overcrowding as we will have less delay. Using a QR code scanner included in the tablet we will be able to maintain the queue. Thus, a convenient ticketing system is maintained, and also since we are using modern technology so we can enable a convenient user interface. Finally, the live location of current buses is also possible. Similar to design 1.

Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two powerful processing units (Tablets) both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, printing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved. Similar to designs 1 and 2 but it has more processing power. This design will have the best performance due to having a higher processing speed.

Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public footpath. The design is not cost-effective due to having higher performance. However, to ensure continuous electric supply we can update our system in the future to run in battery mode during

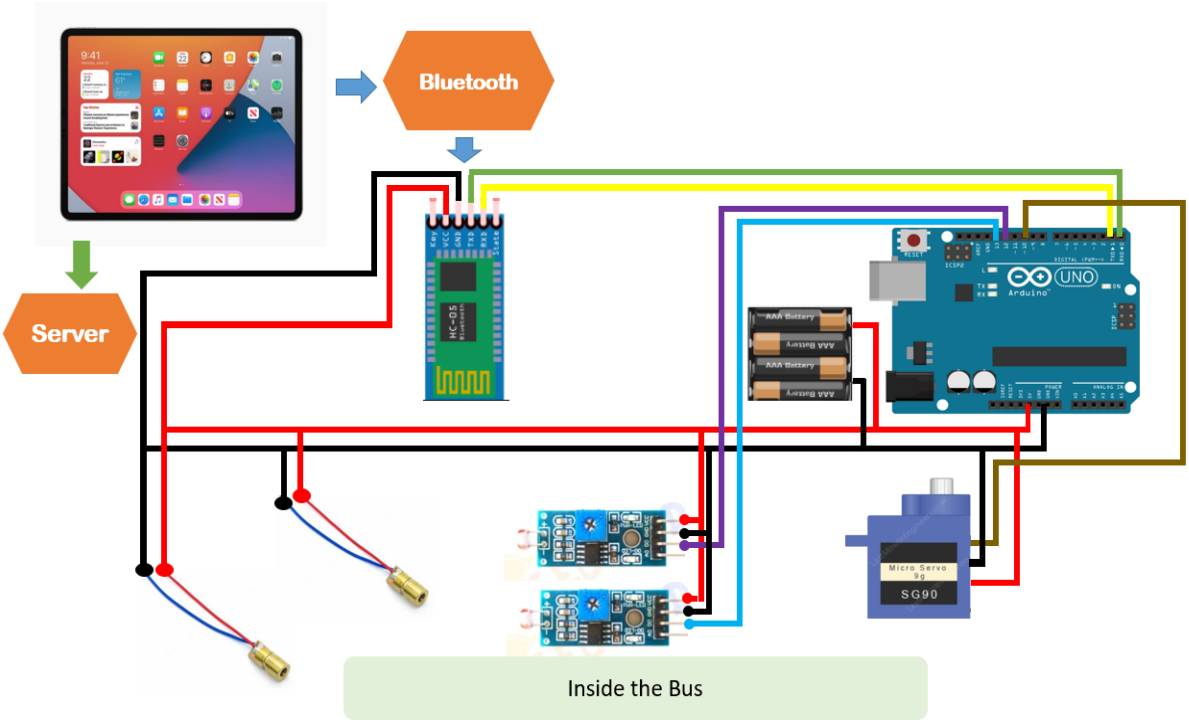
any load shedding and continuous internet connectivity is also ensured if the server runs stable. Similar to previous designs.

Criteria Table and Design Process for Design 5:

Objectives	Requirements	Constraints
✓	✓	Partially Fulfilled

At the Bus Stand:

Inside the Bus:



vi) Design 6: Using Wi-Fi instead of GSM module:

Objective: In this design, we can see that by using standard components we can reduce overcrowding as we will have less delay. Using a QR code scanner we will be able to maintain the queue. Thus, a convenient ticketing system is maintained, and also since we are using modern technology so we can enable a convenient user interface. Finally, the live location of current buses is also possible. Similar to design 1.

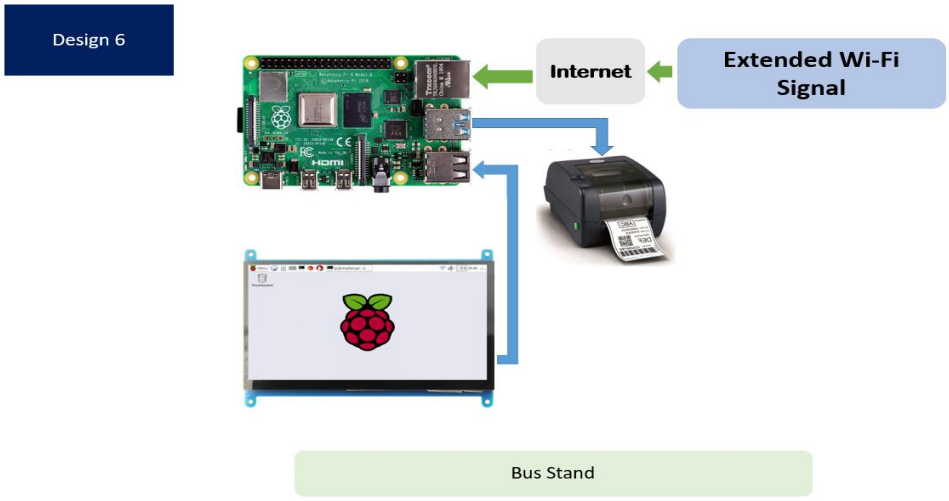
Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two reliable processing units both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, printing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved. Similar to design 1 but using WiFi instead of GSM.

Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public footpath. The design is cost-effective. However, to ensure continuous electric supply we can update our system in the future to run in battery mode during any load shedding and continuous internet connectivity is also ensured if the server runs stable. Similar to design 1.

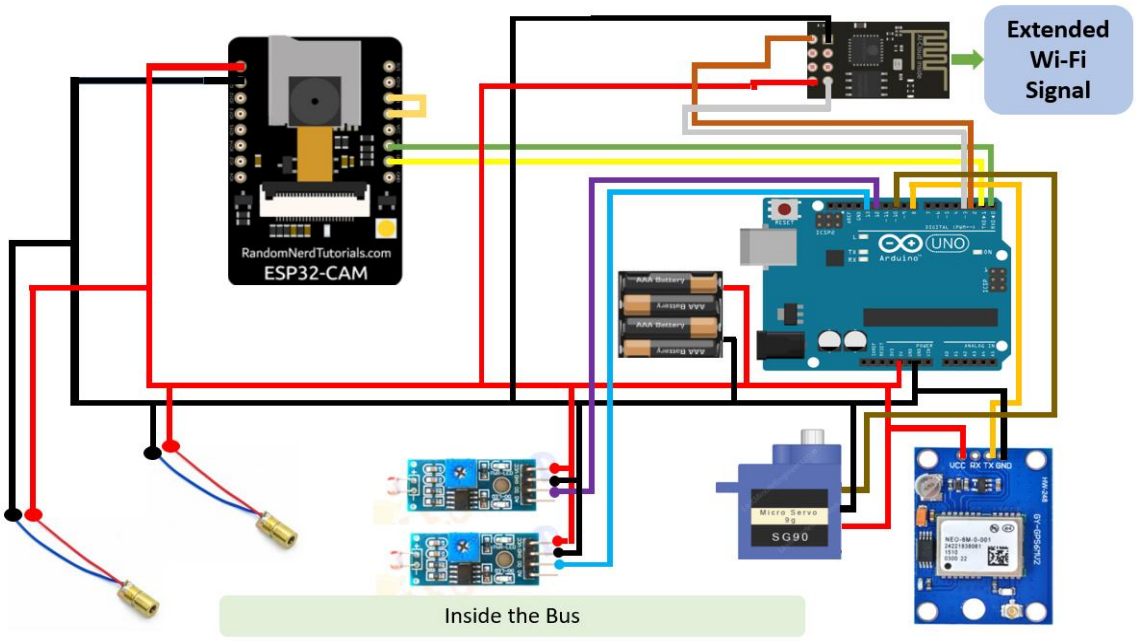
Criteria Table and Design Process for Design 6:

Objectives	Requirements	Constraints
✓	✓	✓

At the Bus Stand:



Inside the Bus:



vii) Design 7: Using RFID module instead of GSM module:

Objective: In this design, we can see that by using standard components we can reduce overcrowding as we will have less delay. Using a QR code scanner we will be able to maintain the queue. Thus, a convenient ticketing system is maintained, and also since we are using modern technology so we can enable a convenient user interface. Finally, the live location of current buses is also possible. Similar to design 1.

Requirements: To solve the problem, we see that all the requirements needed are fulfilled for the subsystem as we are enabling two powerful processing units both at the stand and inside the bus which can control all the necessary applications to solve the problem. Ticketing, printing, monitoring, bus tracking, current passenger tracking, wireless data transfer, and a controlled door entry are all possible in this design. Since the requirements are fulfilled, we can say that our problem can be solved. Similar to design 1 but using Radio frequency module instead of GSM to transfer data. In our literature review, we mentioned that RFID performs better than GPS in terms of low power consumption and cost. However, such a device is not efficient when compared to GPS performance. So, we are considering another module of RFID which can be used for wireless data transfer by replacing GSM. This module is an updated version of the RFID module being used as a data transfer rather than as a vehicle tracker.

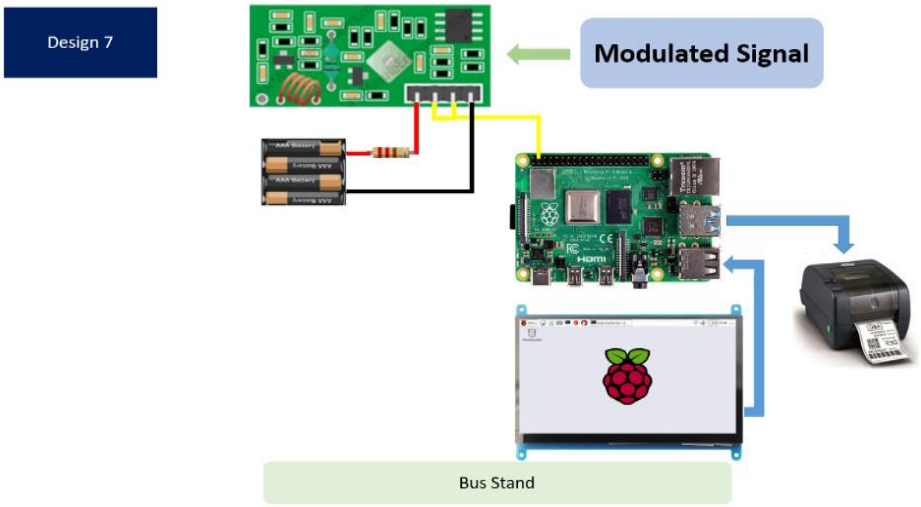
Constraints: In order to implement the solution, we see that using this design no unauthorized will be permitted since the user must need a ticket to enter only at the bus stand. It has a simplified interface which makes it convenient for troubleshooting. It consumes less space in a public

footpath. The design is cost-effective. However, to ensure continuous electric supply we can update our system in the future to run in battery mode during any load shedding and continuous internet connectivity is also ensured if the server runs stable. Similar to design 1.

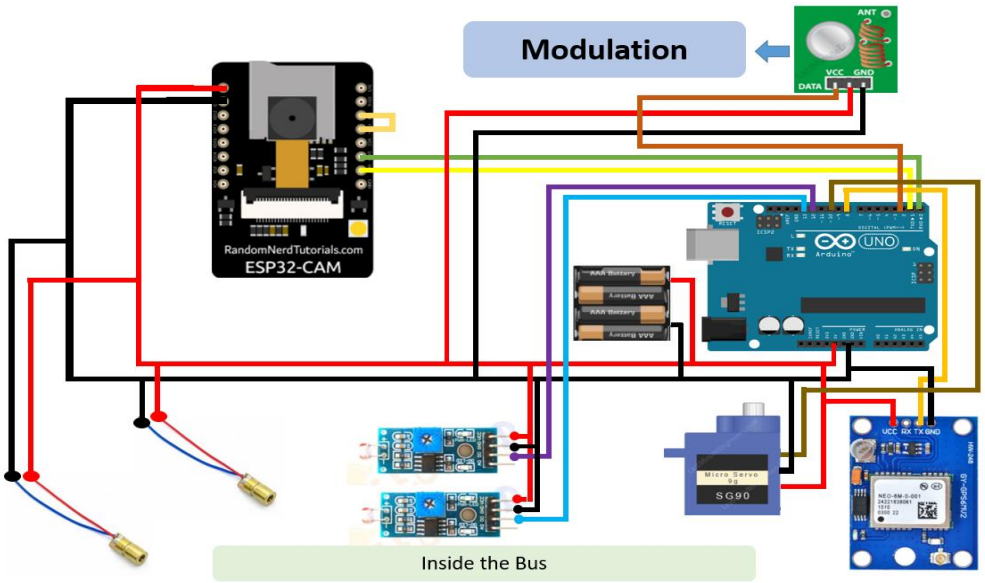
Criteria Table and Design Process for Design 7:

Objectives	Requirements	Constraints
✓	✓	✓

At the Bus Stand:



Inside the Bus:



2.4 Analysis of multiple design approach

For Design 1: Using GSM & GPS

In this design, we are using standard components to solve our problem. Here, we will be using a Raspberry Pi to control the bus stand and an Arduino to control inside the bus. A GSM and GPS module is used to transfer location and current passenger information more efficiently. Using a GSM module helps to solve a range of data issues and both GSM and GPS are widely used in many applications. Furthermore, GSM has high bandwidth (Rate of data transfer, bps) for SIM800l we will get a bandwidth of about 85.6 kbps (from the datasheet). In terms of scanning, a QR code scanner is used which is popular and widely available. Since our system will provide a printed ticket in a queue through online transactions so, this will not create massive discomfort to users. Furthermore, this system is future upgradable as we are using modern technology and easy to maintain as less complicated equipment is seen. Here, all users can access it with any mobile device. Using this design will enable the system to have less delay, quick compensation for any transaction issues, quick repairs, and updates. Finally, users can also see their desired bus locations from the bus stand. Thus this system will have greater efficiency.

Detailed Analysis for Design 1							
Cost **(Within the Budget.)**	**Efficiency** **(Provide maximum performance.)**	**Usability** **(Satisfying users. User friendly system.)**	**Manufacturability** **(Available components.)**	**Impact** **(Does not create discomfort for both users and society.)**	**Sustainability** **(Design must be future proof with less waste generation.)**	**Maintainability** **(Easy troubleshooting.)**	**Accessibility** **(Compromising both users and the system. Easy access for users and quick response of the system.)**
✓	✓	✓	✓	✓	✓	✓	✓

For Design 2: Using Raspberry Pi inside the bus instead of Arduino Uno

In this design it is almost close to the previous design no. 1, as we are using the same components, the only difference is that it has a Raspberry Pi instead of an Arduino inside the bus. This will improve the performance of the system but on the other hand, it will increase the cost. Furthermore, this will also increase complexity in the system as Raspberry Pi is a bit difficult to interface with due to some of its restrictions and not that available. In terms of user interface, accessibility and maintenance all of them are convenient to run efficiently.

Detailed Analysis for Design 2							
Cost **(With in the Budget.)**	**Efficiency** **(Provide maximum performance.)**	**Usability** **(Satisfying users. User friendly system.)**	**Manufacturability** **(Available components.)**	**Impact** **(Does not create discomfort for both users and society.)**	**Sustainability** **(Design must be future proof with less waste generation.)**	**Maintainability** **(Easy troubleshooting.)**	**Accessibility** **(Compromising both users and the system. Easy access for users and quick response of the system.)**
✗	✓	✓	✗	✓	✓	✓	✓

For Design 3: OTP based system (One Time Password)

In this design it is almost close to the previous design no. 1, as we are using the same components, the only difference is that it has a password keyboard instead of a QR scanner inside the bus. This system is quite similar to an ATM machine as mentioned above. This will create less impact on the passengers who are used to ATM transactions. However, if a wrong entry is provided then this system will create a huge delay as passengers need to type the password again and again. Thus this will lead to discomfort for other passengers since there is a huge chance to create a huge delay. This system can be upgraded to any convenient system to fulfill the needs of the customers. Moreover, this system is cost effective, easy maintenance, widely available components but not an efficient solution.

Detailed Analysis for Design 3							
Cost (Within the Budget.)	**Efficiency (Provide maximum performance.)**	**Usability (Satisfying users. User friendly system.)**	**Manufacturability (Available components.)**	**Impact (Does not create discomfort for both users and society.)**	**Sustainability (Design must be future proof with less waste generation.)**	**Maintainability (Easy troubleshooting.)**	**Accessibility (Compromising both users and the system. Easy access for users and quick response of the system.)**
✓	×	×	✓	×	✓	✓	×

For Design 4: App-Based E-Ticketing System

In this design, we will be modifying design 1 and include an app-based system for all transactions and soft copies of tickets in QR codes. These tickets will be displayed on the smartphones of the users. Here, there is no need for a printed ticket to scan at the bus door. However, in order to use this system, we must make sure that every user must possess a smartphone. If that is the case, then this will create discomfort for some users who are not used to smartphones. In addition, this design will also create complex server installation and app user interface designs. So, this design will consume a long duration to complete and there might be a high probability of the server getting jammed due to the complexity. This will lead to a huge delay as troubleshooting is not convenient compared to other designs. Thus this design is not an efficient solution. This system can also be upgraded to any convenient system to fulfill the needs of the customers.

Detailed Analysis for Design 4							
Cost (Within the Budget.)	**Efficiency (Provide maximum performance.)**	**Usability (Satisfying users. User friendly system.)**	**Manufacturability (Available components.)**	**Impact (Does not create discomfort for both users and society.)**	**Sustainability (Design must be future proof with less waste generation.)**	**Maintainability (Easy troubleshooting.)**	**Accessibility (Compromising both users and the system. Easy access for users and quick response of the system.)**
✓	×	×	✓	×	✓	×	×

For Design 5: Using Tablet phones instead of using individual controllers

In this design, we will be using two tablets to process the entire system. All interfacing such as GSM, GPS, QR code scanning will all be performed using the tablet inside the bus. This will reduce the installation time due to less complexity. However, in terms of budget, this design is way beyond even though this will give the best performance. Here, we see there is a tradeoff between budget and high performance. This design will represent almost design 1 but in a reduced form. Thus this will be less impactful to the users. As this design is very expensive we will not be able to generate mass production. Furthermore, there will be expensive repairs that we can not afford immediately, so this design will consist of more maintenance time. But on the bright side, this design will fulfill all users needs, with fewer delays, and quick access, etc.

Detailed Analysis for Design 5							
Cost **(Within the Budget.)**	**Efficiency** **(Provide maximum performance.)**	**Usability** **(Satisfying users. User friendly system.)**	**Manufacturability** **(Available components.)**	**Impact** **(Does not create discomfort for both users and society.)**	**Sustainability** **(Design must be future proof with less waste generation.)**	**Maintainability** **(Easy troubleshooting.)**	**Accessibility** **(Compromising both users and the system. Easy access for users and quick response of the system.)**
✗	✓	✓	✓	✓	✓	✗	✓

For Design 6: Using Wi-Fi instead of GSM module

In this design, the design is similar to design 1. However, the only difference is that it consists of a Wi-Fi module instead of a GSM module. This design can provide fast data transmission with a very limited range. To increase the range a range extender can be used but this will increase the cost and complexity of the system. Now, Wi-Fi can be used for developed countries where it is widely used since it can provide a bandwidth of 25 Mbps at 2.4 GHz. Because we have a limited range of data transmission, we are not able to get an efficient solution. If we do this design, it will include more cost and complexity.

Detailed Analysis for Design 6							
Cost (Within the Budget.)	**Efficiency (Provide maximum performance.)**	**Usability (Satisfying users. User friendly system.)**	**Manufacturability (Available components.)**	**Impact (Does not create discomfort for both users and society.)**	**Sustainability (Design must be future proof with less waste generation.)**	**Maintainability (Easy troubleshooting.)**	**Accessibility (Compromising both users and the system. Easy access for users and quick response of the system.)**
✗	✗	✓	✓	✓	✗	✗	✗

For Design 7: Using RFID module instead of GSM module

In this design, the design is similar to design 1. However, we are using an RFID module instead of a GSM module. Using RFID, we can ensure low cost and power consumption but in terms of performance, this design will not be an effective solution. As it has a very limited range and bandwidth of about only 4 kbps at 433 MHz. This design will generate huge delays and server crashes. To improve it, we can do some modulation techniques (AM, FM, DM, or PM) to transmit at a higher range but this will include more cost and complexity. Overall this design is very inefficient to fulfill all of our goals.

Detailed Analysis for Design 7							
Cost (Within the Budget.)	**Efficiency (Provide maximum performance.)**	**Usability (Satisfying users. User-friendly system.)**	**Manufacturability (Available components.)**	**Impact (Does not create discomfort for both users and society.)**	**Sustainability (Design must be future proof with less waste generation.)**	**Maintainability (Easy troubleshooting.)**	**Accessibility (Compromising both users and the system. Easy access for users and quick response of the system.)**
✗	✗	✗	✓	✗	✗	✓	✗

2.5 Conclusion

By following the desired objective, requirements and constraints, multiple design approach has been possible. Each one shows specific satisfaction to obtain those conditions and with further research and development specification of components has been selected to complete the detailed design. Later on, each design has their own pros and cons so that is why all of them have been analyzed even further to satisfy multiple variables.

Chapter 3: Use of Modern Engineering and IT Tool.

3.1 Introduction

In the previous section, multiple design approaches were discussed with their respective objectives, requirements, and constraints. Now in order to analyze them, we need to consider some essential tools. A detailed table is given below, there we can see, we have two sections one is for software and another one is for hardware. To perform the hardware analysis, we will need all the hardware tools needed to implement correctly. Then comes the software part.

3.2 Select appropriate engineering and IT tools

	Name	Purpose	Validation
Software	Arduino IDE	Program Arduino Uno for scanning, receiving GPS data and sending it to server using GSM.	Programming all the modules.
	Adobe Xd	Designing a User interface system for user convenience.	Providing dynamic UI.
	Raspbian OS	Lightweight O.S to run the entire bus stand.	Fast response at bus stand.
	Proteus	Supports third party library for simulation.	Output with animation.
	U-center	Testing GPS modules accuracy and location sensing potential.	Detected Signal accuracy and location.
	ThinkSpeak website	Storing data received from bus.	Successfully stored latitudes, longitudes and occupancy.

	Name	Purpose	Validation
Hardware	Soldering Iron	To ensure strong connection from one module to another.	Successfully connected all necessary connections.
	Multimeter	To measure all voltage ratings to enable safe thresholds.	Enable all correct ratings.
	Bolts and Nuts	To secure all components in a complete system.	Ensuring easy swappable components.
	Screw Driver	To tighten all the bolts and nuts.	To prevent over tightening.
	Hot glue	To complete the infrastructure and attach permanent components.	Ensuring structural integrity.
	PVC board	To develop the outer case to place our hardware components.	Easy accessible and feasible.

3.3 Use of modern engineering and IT tools

Here, initially, we used proteus to check some verifications. However, proteus supports animation and outside libraries with limitations. For our case, we could not do a complete simulation due to the limitations of the library. While analyzing, we found that the proteus software does not give changing values rather it gives a static value that does not fulfill our purposes. A depth analysis will be given on the analysis part of the report where we will discuss one of the main requirements of our design and that is the range of data. In proteus, we cannot verify the range. Therefore, we used Proteus to get an estimated idea about the components we are going to use in terms of interfacing, programming, etc. Next comes Adobe Xd, here it is used to design the user interface of our ticket vending system. It is used instead of other software as it has dedicated features in terms of designing the user interfaces. Next comes the Arduino IDE, as we will be using an Arduino Uno inside in the bus for most designs except one that replaces Arduino with a Raspberry Pi 4, we will be doing multiple programming using Arduino IDE to complete necessary interfacings. Furthermore, at the bus stand, we will be using a Raspbian OS to control the Raspberry Pi. By using think speak website we can store our desired data in a server. Using a GSM module we have an internet connectivity, thus makes our data transfer simple.

3.4 Conclusion

To sum it up, we will be using all the above methods and tools to design efficiently. However, we will not be able to test every one of our designs in that software due to the limited library and impractical results in proteus. So, we will firstly, verify the data sheets of some important modules like GSM and GPS data range, rate and bandwidth and compare with other designs and find our optimal approach. Furthermore, an UI is implemented in such a way that users can purchase their tickets and the latest count can be stored. A database system is developed to ensure proper data transfer.

Chapter 4: Optimization of Multiple Design and Finding the Optimal Solution.

4.1 Introduction

Now, that we have selected our engineering tools to implement our design so, now we need to find the optimal solution from multiple designs. To do that a table is given, which includes multiple conditions with a certain point. The design receiving the maximum points will be considered as an optimal solution. After selecting the optimal solution, we need to perform some test cases to validate the optimal design.

4.2 Identify optimal design approach

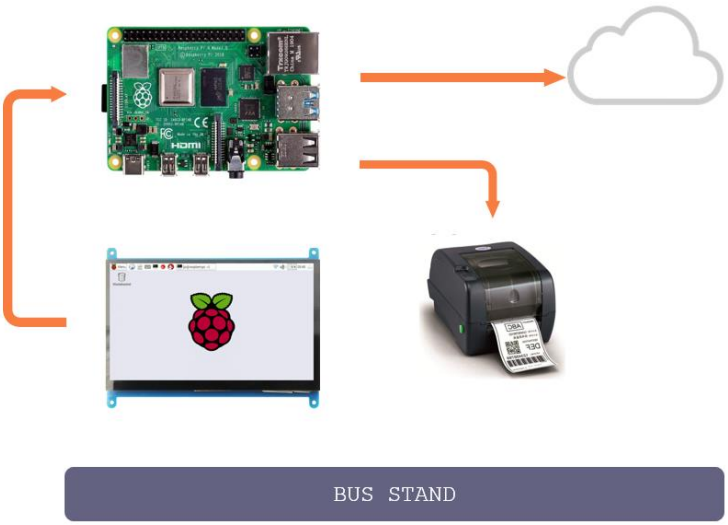
Designs	Range of Data (Bandwidth) [Out of 30]	Usability User's Perspective [Out of 20]	Budget (Does not Exceed) [Out of 15]	Maintenance (Easy Troubleshooting) [Out of 10]	Accessibility (Compromising both users and system) [Out of 25]	Total Rating [Out of 100]
1. GSM & GPS	85 kbps At 850 – 1900 MHz	Convenient	Satisfied	Simple	Satisfied	**[96]**
	[29]	**[18]**	**[15]**	**[10]**	**[24]**	
2. Raspberry Pi instead of Arduino	85 kbps At 850 – 1900 MHz	Convenient	Exceeded	Simple	Satisfied	**[93]**
	[29]	**[18]**	**[12]**	**[9]**	**[25]**	
3. OTP	85 kbps At 850 – 1900 MHz	Inconvenient	Satisfied	Simple	Unsatisfied	**[82]**
	[29]	**[11]**	**[15]**	**[9]**	**[18]**	
4. App Based	85 kbps At 850 – 1900 MHz	Inconvenient	Satisfied	Complex	Unsatisfied	**[74]**
	[29]	**[10]**	**[15]**	**[5]**	**[15]**	
5. Smart Tablet	20 mbps At 3 - 8 GHz	Convenient	Exceeded	Complex	Satisfied	**[80]**
	[30]	**[18]**	**[0]**	**[5]**	**[25]**	
6. Wi-Fi	25 mbps At 2.4 GHz	Convenient	Exceeded	Complex	Unsatisfied	**[77]**
	[30]	**[18]**	**[5]**	**[6]**	**[18]**	
7. RFID	4 kbps At 433 MHz	Inconvenient	Exceeded	Complex	Unsatisfied	**[42]**
	[10]	**[5]**	**[12]**	**[5]**	**[10]**	

Therefore, the design 1 GSM & GPS is our optimal solution as it has the highest points.

4.3 Performance evaluation of developed solution

To complete the performance evaluation, we need to test two sub systems of our optimal in multiple sections.

<u>Bus Stand:</u> System Setup with Raspbian O.S. with a dedicated User interface.



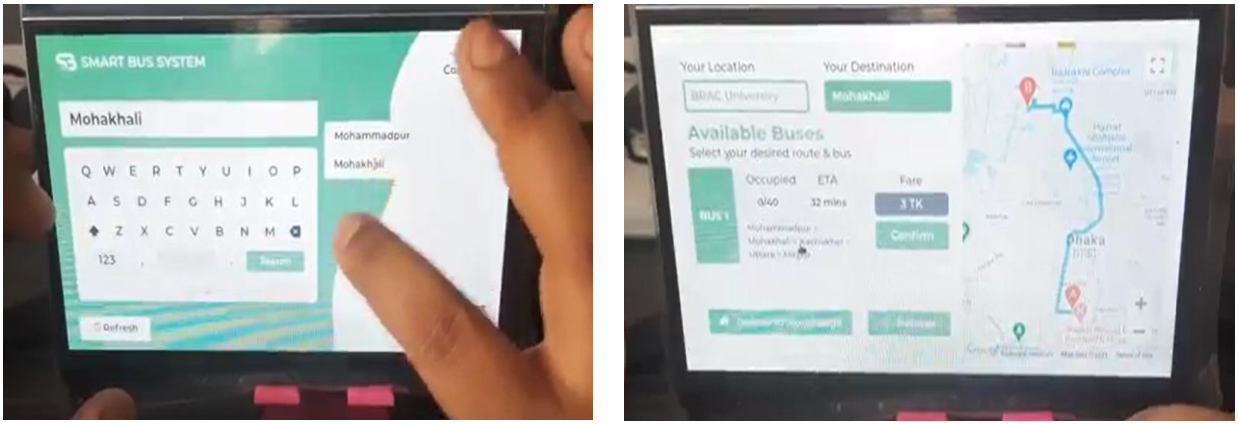
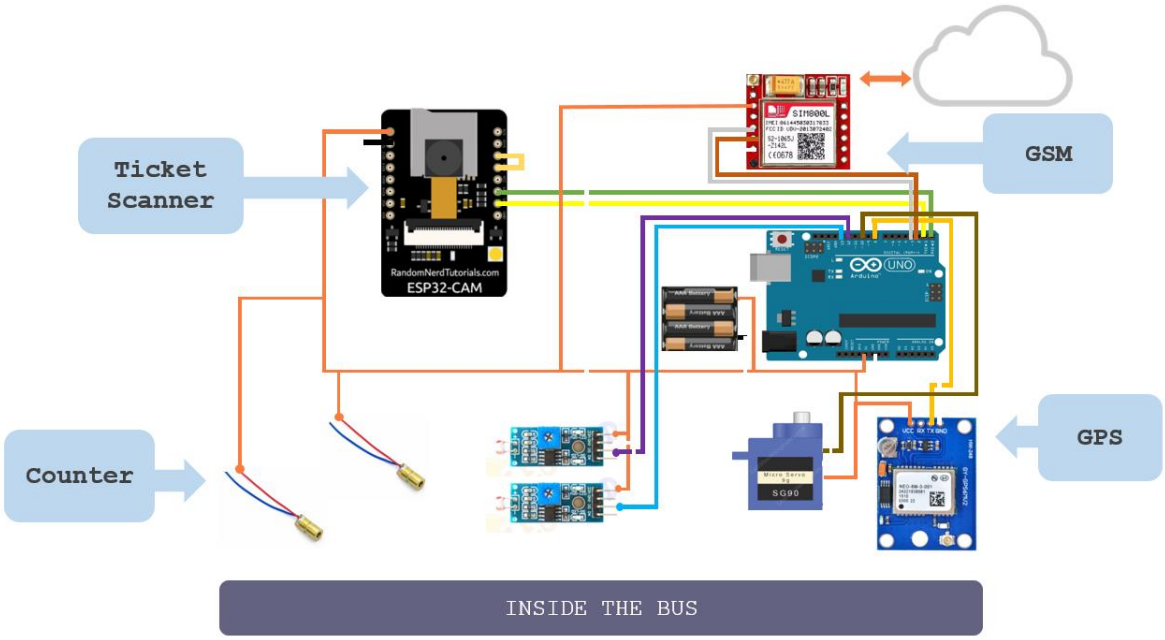


Fig: Ticket vending system.

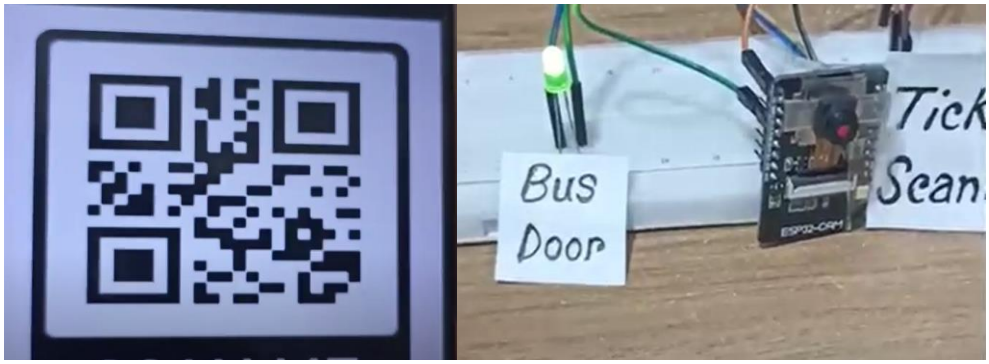
<u>Inside the Bus:</u> Separated into 4 sections (Ticket Scanner, GSM, Counter and GPS.)



Ticket scanning verification test:

The ESP32 CAM has a camera with integrated AI. This allows various camera functions to be utilized. For our case, we are using it to scan QR code to trigger our servomotor. Thus, unauthorized entry is prohibited.

The major problem to use this module was to upload the program to the ESP32 and to trigger the servomotor. However, by using a method called flashing (erases all previous data in any controller) we were able to upload our code.



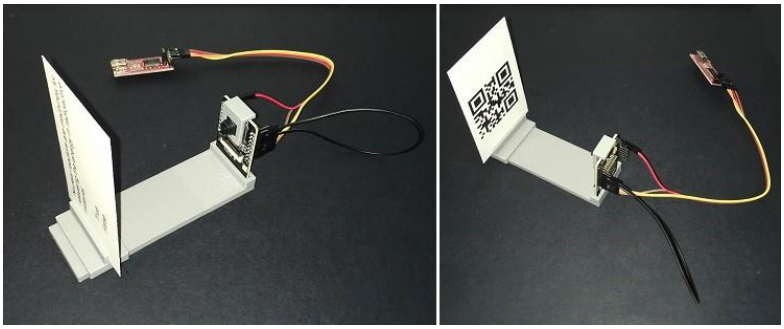


Fig: Ticket scanning using QR code.

Counting current passengers verification test:

Here, two laser dot diodes and LDR sensors are used to detect the latest count. This allows to detect the entered passengers and leaving passengers. Thus, we can get latest number of passengers to send it to our server.

The problem we encountered is that the current count was received due to presence of some delay.

Fig: Laser Dot Diode

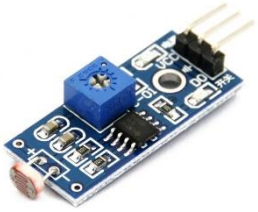


Fig: LDR sensor

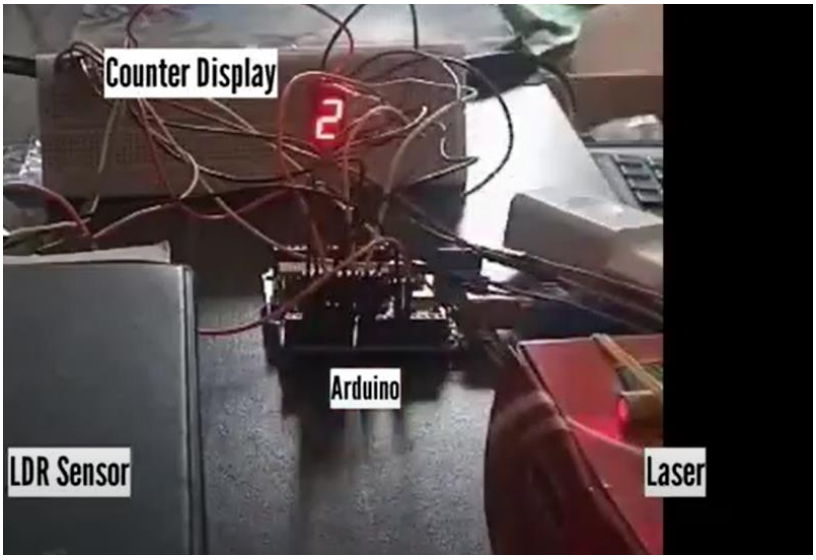


Fig: Counting Mechanism

GSM & GPS data verification using Think Speak database:

Now, one of the most important part of our project is to provide a data storing potential. Nevertheless, before the data is stored it must be transferred through a wireless medium. For our case, we are using a GSM module as it has the maximum range of data transfer.

One of the major problem to test the GSM module was that we were not able to transfer nor receive data. Furthermore, the module we selected SIM800l was a faulty one so we included a new module SIM900A with a powerful antenna to provide maximum output. Finally, it worked as expected.

The problem was also present for GPS module as well. It was not receiving sufficient power to send GPS coordinates. Then by changing it to a powerful antenna, we were able to transfer our data with no problem.

Fig: GSM & GPS module

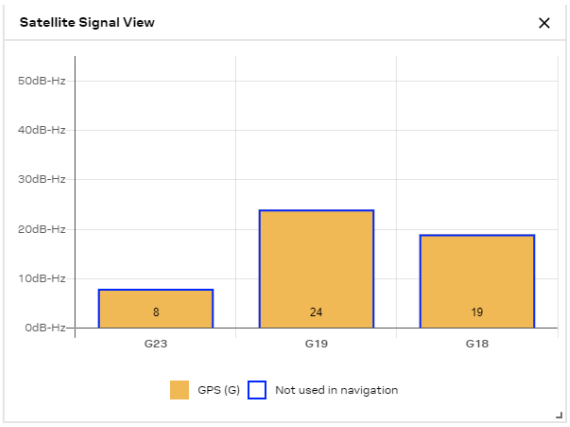


Fig: GPS Data Rate inside House

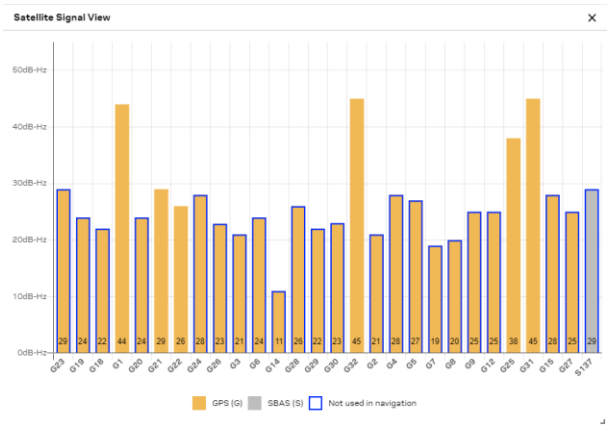
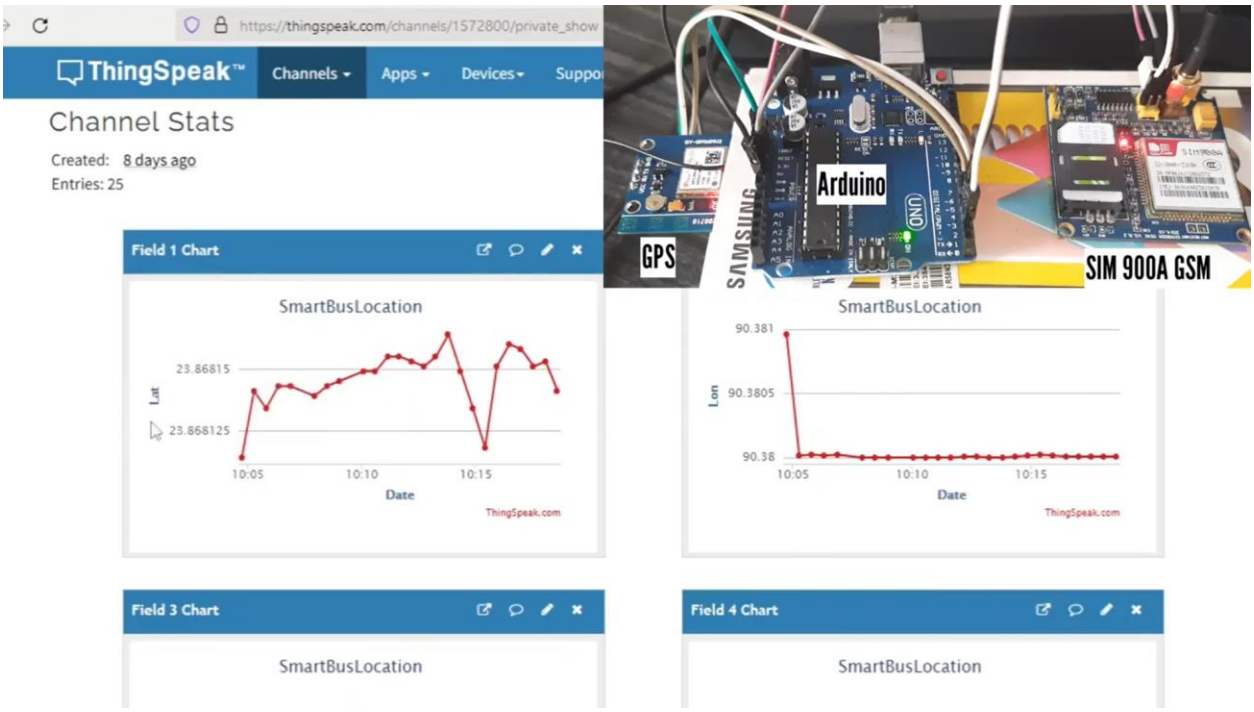


Fig: GPS Data Rate outside House

Think Speak Website:

In the tools selection, think speak website was preferred as it has the potential to store data. For, this project data is initially transferred through GSM module then send to server for being stored. Think speak is used to store all of the coordinates data (latitudes & longitudes). These coordinate helps to track down the bus in real time.



4.4 Conclusion

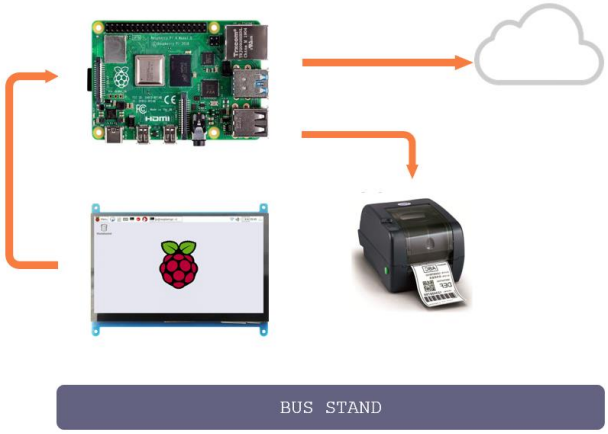
To sum it up, the two subsystems were implemented separately into multiple sections so that the workload can be divided. In each section, there were many issues present to obtain the desired result so, after few trials and research; it was finally working as expected. The ticket vending system was showing all the individual UI components. Furthermore, data transfer through GSM and storing them at think speak website was possible. As, individual components are working at two subsystems so, it can claimed that the entire system is working properly separately. In the next section, entire integration of systems needs to be implemented.

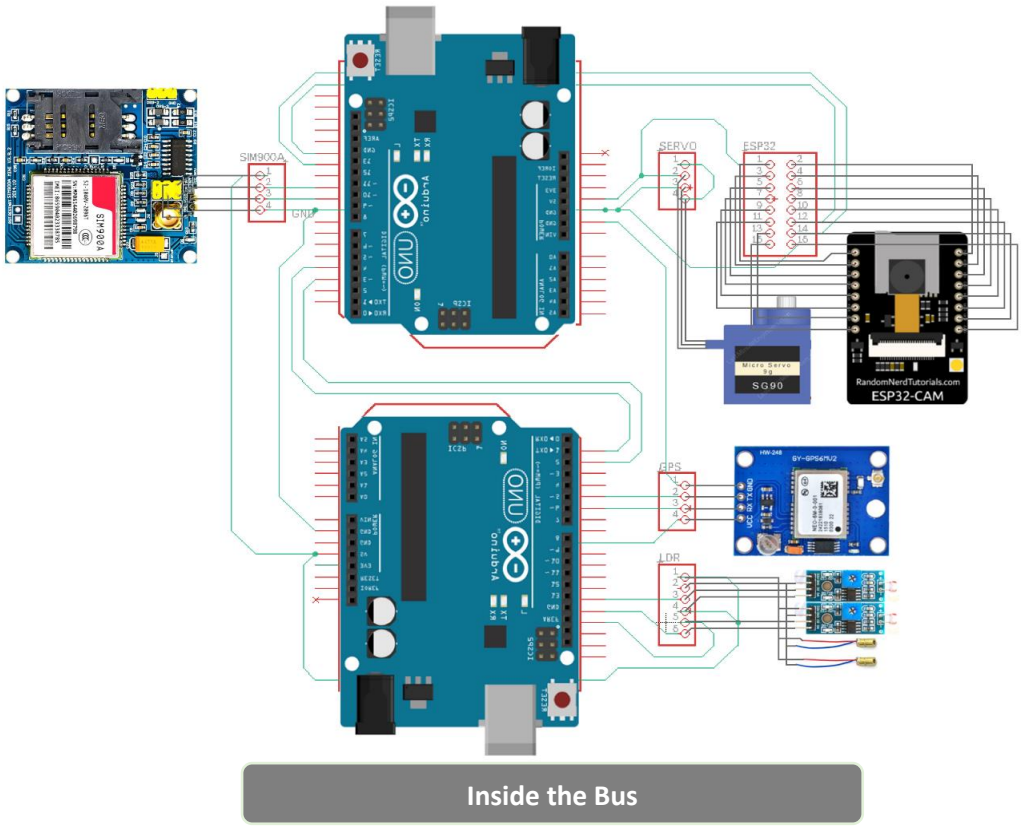
Chapter 5: Completion of Final Design and Validation.

5.1 Introduction

In the previous section, the optimal solution was designed and implemented separately. But unfortunately after integrating every components there was some delay to transfer the GPS data. This then resulted in having a major flaw in this integrated design. Thus, some precautions are taken to improve such problem.

5.2 Completion of final design





This is the final design, which solves the delay problem. Furthermore, a PCB is designed to aid the design as it provides cable management.

PCB design:

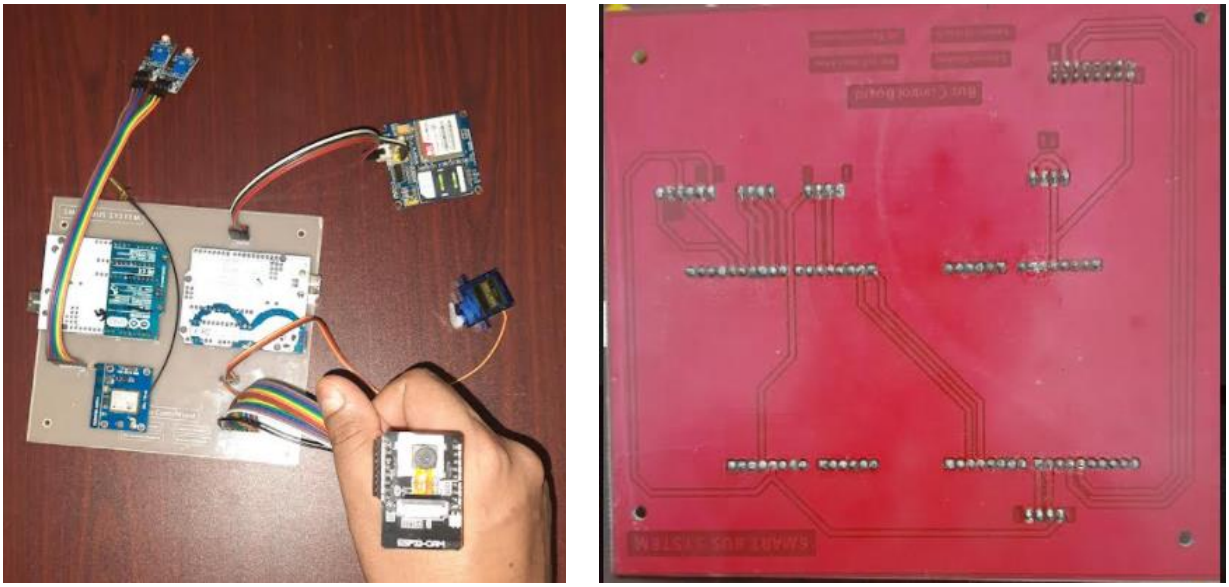


Fig: PCB design of the system. (Inside the bus)

Finally, an enclosed box is design to fix everything.

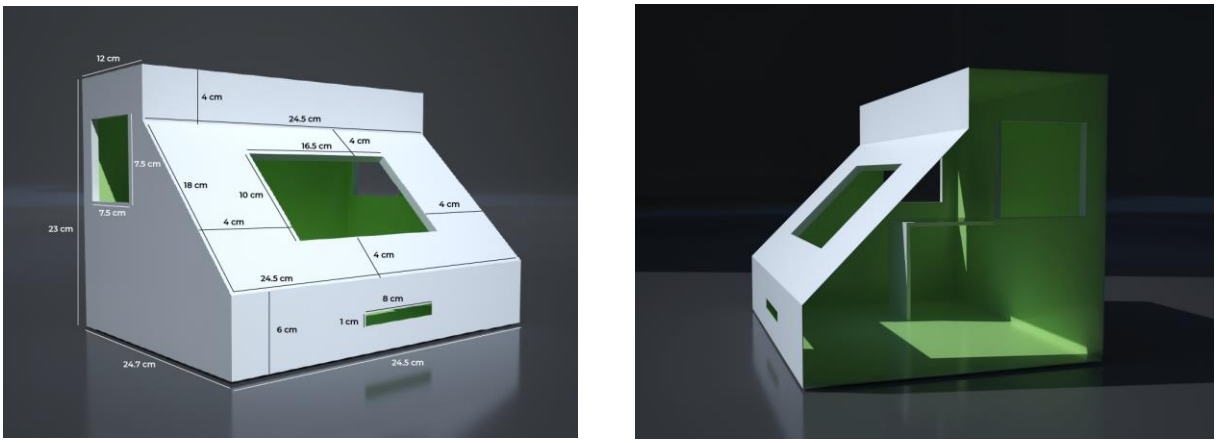


Fig: An enclosed system for bus stand.

5.3 Evaluate the solution to meet desired need

Inside the bus:

A Bus Control Board controls the overall system. It contains several parts including two Arduinos. The Master Arduino (Top Arduino) is connected to a Sim900a GSM module and its job is to get the data from the slave Arduino (Bottom Arduino) and send it to the ThingSpeak server. The slave Arduino is connected to a U-Blox Neo 6m GPS module and Two LDR sensors. The slave Arduino is responsible for taking the data from these two sensors and send them to the master Arduino using serial communication. The working process starts with getting data from the GPS module. The module initially takes some time to get a fix on GPS satellites. After getting the fix, it starts to transmit the coordinates to the slave Arduino. At the same time the two LDR sensors counts the current number of passenger inside the bus. These two sensors are place side by side at the bus door. When a person enters the bus, as soon as he crosses the outside sensor, increases the count and triggers a delay. So the inside sensor is disabled for a while. Similarly, when a person is getting out of the bus, the inside sensor is activated and it decreases the count and triggers another delay which disables the outside sensors for a while. That is how we can count the current number of passengers inside the bus. So, the passenger count and the coordinates of the bus is sent to the slave Arduino. The data is then sent to the master Arduino from the slave Arduino using serial communication. After getting the data from the slave Arduino, the master Arduino simply connects to the Sim900a module and sends the data to the server. The bus control board also consists of a ESP32 Camera module and a Servo motor. The ESP32 module scans QR code based tickets. The ticket codes are downloaded from the server using the same SIM900A module. If a passenger shows a valid ticket, the ESP32 Camera module sends a signal to the servomotor, which is connected, to a door inside the bus. The door opens and thus the passenger can now enter.

Bus Stand:

The components of the Bus Stand is comparatively simple. Here the ticket vending machine consists of a Raspberry Pi 4 (2 GB), a 7” touchscreen display and a printer. The Raspberry PI is connected to the internet via Wi-Fi. It is responsible for running the Laravel based Smart Bus System web application. Passengers can select their destination, number of tickets from this vending machine. They can also view the bus locations real time. They can buy the tickets using digital payment method. After purchasing the ticket the will get a printed copy of the ticket which will be used to scan in the ticket scanner of the bus.

5.4 Conclusion

To sum it up, it is seen that the final design satisfies all the requirements effectively. Some flaws were seen due to the presence of delay after integration. Afterwards, with more trails and debugging the desired result was achieved. To keep the entire system clean, a PCB is used for cable management with an enclosed box. Thus, this will resemble exactly like a final product.

Chapter 6: Impact Analysis and Project Sustainability.

6.1 Introduction

To launch a new initiative there are always some concerns about how it will be appreciated by the public. So, to satisfy them compromising is mandatory aspect to solve such conflicts. This a challenging stage as this will involve societal, cultural, environmental changes and this will raise concerns among users. Their feedback is the backbone of our project.

6.2 Assess the impact of solution

People always want an improved life. As our project is bringing a new era in the field of bus transportation systems of Bangladesh, general people will feel that society is improving. There will be enough space for the user in front of the vending machine. Therefore, there will be no chance of crowdedness. This system is very organized. People will come to the counter, collect tickets from the vending machine automatically & then get on the bus maintaining the queue. Therefore, it will not be a difficult situation like the current system where getting on or off a bus is very risky. As there are no proper, ticket counters for local buses and the management is very poor, our system will have a good impact. After collecting the ticket, people will get on the bus by showing their tickets. They will get enough time to get on the bus properly. Therefore, there will be no safety issues. All the legal process is sincerely taken care of by our lawyer who will ensure that no law is broken by our project. Contracts with different organizations, contracts with the government will be very carefully maintained in the legal system. Proper testing of the overall system will be done rigorously to ensure that the system performs up to the expectations and within safety margins. We will choose appropriate locations for the bus stop, which will not interfere with the vehicles or pedestrians by obstructing their way. The citizens of Bangladesh are already familiar with ATMs and other types of vending machines. Therefore, our system will provide a comfortable experience to the users and help yet another sector advance towards autonomous operation with the help of advanced technologies. Therefore, we hope this project will be an important part of their modern life.

6.3 Evaluate the sustainability

In this project, we are implementing in such a way so that we can further upgrade our system in the future with a minimum budget. We are using microcontrollers to handle stress, as it will be implemented in the public area. Moreover, in our project, we are using an adapter at the bus stop, which leads to having a continuous electric supply. Unfortunately, in Bangladesh load shedding is a common phenomenon. As a result, not having a continuous electric supply, our bus stop cannot provide tickets for new passengers, which might create public impatience. Thus, this will lead to

having an unfriendly environment. Furthermore, the implementation will consume a certain area, which will not reveal a friendly environment for rush hours due to the presence of a large queue. For our current project, we are relying on an adapter for continuous electric supply but a battery with a dedicated solar charger will replace this in the future and the presence of a large queue is temporary and will only be seen at the rush hours. For our prototype, we will consider only a battery and a dedicated adapter.

Sustainability Matrix:

Ethical Theory	Overall Objectives	Interest Group	Sustainability Objectives
Utilitarianism	Solar power	Users	Providing a hybrid power supply.
Utilitarianism	Backup Battery	Users	Storing the charges from solar cells to provide longer backup.
Utilitarianism	Uses of renewable energy	Environment	Reducing the generation of waste as much as possible.
Utilitarianism	Future Upgradeable	Users and System	Improving the system with respect to time in an inexpensive manner.

6.4 Conclusion

To clarify, to develop something it is an uncertain initiative as the feedback from users may vary and thus it will create huge problem to manage the project. If everything goes efficiently, then there will be a bright future of this project. This will allow making necessary plans and upgrades of the system in future.

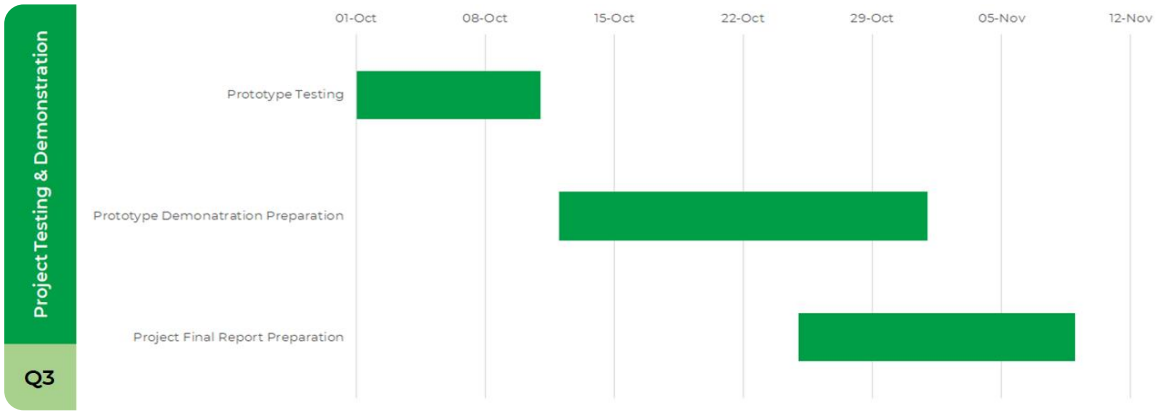
Chapter 7: Engineering Project Management.

7.1 Introduction

Project management is a crucial aspect to show the entire progress of the designed plan. Whenever a project is decided organizing it becomes challenging as it the backbone of any project. That is why, when a project is planned there are multiple stages where the designed plan may not give accurate outcomes due to some issues or some risk factors. A backup plan is estimated prior to start any project for any type of associated risks. Everything is managed by assigning specific responsibilities. Teamwork is the key to solve any risk factors and keep generating a constant output.

7.2 Define, plan and manage engineering project

i.) Initial Plan:



ii.) Updated Plan:

Risk Management and Contingency Plan

Risk is an uncertain moment, where it could bring multiple unknown consequences. Various risks such as design malfunction, short circuit by accident, damage of any expensive components, server jam, etc. might occur if there is an accident. Therefore, in order to manage such risks, we are dividing our responsibility on particular issues.

Risk Response Matrix:

Risk Event	Response	Contingency Plan	Trigger	Who is responsible	Worst Case
Interfacing Problems	Mitigate: Test the prototype to find the problem.	Immediately, stopping the problem from spreading and solving it as much as possible.	Not solved within 2 days.	MD. Asif Imran Khan	Same issues at the final product.
System freezing	Mitigate: Test the prototype to find the problem.	Recheck the connections and restart the system if required.	Frozen still after 2 days.	Salamun Kawlam	User discomfort.
User backlash	Mitigate: Observing the entire problem and trying to find the optimal solution.	Reallocating the resources and selecting the best-improvised decision.	Unable to manage resources and budget.	Jannatul Nayeem	Huge delay to fix the problem.
Equipment malfunction	Mitigate: Select a reliable seller providing a warranty.	Order replacement.	Equipment fails.	Rezwan UL Quadir	Entire system will collapse if delayed.

7.3 Evaluate project progress

Project management is compulsory when a project is implemented effectively. To maintain a constant outcome by completing any task a progress is observed. Tasks are all assigned in a planned manner. Initially, a plan is made with estimation but unfortunately, it did not went according to plan as there were some issues regarding component testing. Therefore, a new updated plan has been designed with new timeline. This will hopefully bring accurate progress of the project. Furthermore, responsibility has been assigned to each members to divide the workload. Moreover, as risk is an uncertain case so, backup plan is compulsory to manage resources. For our project, we faced some component damage and trouble shootings while implementing. Therefore, to continue effectively precautions were taken from our designed contingency plan.

7.4 Conclusion

To sum it up, project management becomes a backbone while doing any kind of project. It helps to organize the plan and gain the progress. Estimated plan created issues while demonstrating so, a new organized plan is implemented. Including risk management is also another important part of project management, which shows a backup plan to manage effectively. Sometimes improvising is necessary to achieve a quick solution in a limited time.

Chapter 8: Economical Analysis.

8.1 Introduction

The study of economic systems is known as economic analysis. It could also be an investigation into a manufacturing process or an industry. The goal of the analysis is to identify how well the economy or a component of it is performing. An economic examination of a corporation, for example, focuses mostly on how much profit it generates. Furthermore, it also allows estimating the business outcomes through data driven techniques, convenient decision making and shows the best way to utilize resources.

8.2 Economic analysis

Economic analysis is a tool for assisting in the better allocation of resources, which can result in increased income for investment. An economic analysis purpose for businesses is to present a clear picture of the current economic condition. What effect, if any, the current economic climate has or will have on the company's capacity to function commercially. For this project, as a smart bus system is implemented so, to establish such system requires huge resource management. This enables an effective method to reach the desired goal. The entire is constructed in such a way that mass production is possible because prototyping costs more rather being produced in mass quantity. After implementation, one of the most important aspect is maintenance. To provide maximum maintenance and support to customer, new employment origin takes place. Hiring new people allows maintaining the resources and customer support at all time. Regular customer compensation and compromise is possible.

8.3 Cost benefit analysis

By cost benefit analysis, feasibility verification of a project is estimated, which gives a vision for the organization in terms of present, future and risk factors. For this project, the selected design has a dedicated strength and weakness in performance and management. Each components has its own pros and cons (strength and weakness) to work effectively. Moreover, management must be given greater emphasis as customer satisfaction, competition and strategies can create immense impact of an organization. A table is given for further analysis:

Components	Price	Strength	Weakness
1. Raspberry Pi 4 Computer (2GB)	5500	• Powerful processing unit. • Future proof. performance. • Supports display ports (HDMI)	• Expensive repair. • More delay to fix the problem.

2. Raspberry Pi 7inch HDMI Touchscreen LCD with Case	4880	• Wide dimension. • Better visible. • Lightweight. • Future proof.	• Might break for careless activity. • Expensive repair. • More delay to fix the problem.
3. SIM900A GPRS GSM Module	1450	• High Bandwidth. • Robust module. • Better wireless range. • Future proof.	• Sensitive to overvoltage. • Expensive repair.
4. U-Blox NEO-6M GPS Module	845	• Better coordinates to track vehicles.	• Expensive repair. • Sensitive to overvoltage.
5. ESP32-CAM WiFi + Bluetooth Camera	995	• High potential to scan QR codes.	• Expensive repair. • Sensitive to overvoltage.
6. Arduino UNO R3 x2	1140	• Central processing unit for bus. • Future proof. • Easy swappable. • Low cost.	• Medium processing power.
7. SG90 9G Micro Servo Motor x1	180	• Preventing unauthorized entry. • Cheap and widely available.	• Medium torque.
8. Laser DOT Diode x2	50	• Cheap and widely available.	• Weak design thus need protection shield.
9. LDR x2	130	• Current passenger count possible. • Cheap and widely available.	• Sensitive to overvoltage.
10. Antenna x2	798	• Provides stronger signal.	• Weak design thus need protection shield.
11. HP Desk Jet Printer	3500	• Printing QR codes.	• Expensive repair. • More delay to fix the problem.
12. Structure	6000	• Robust infrastructure. • Surveillance.	• Regular maintenance. • Security expenses.

Here, all of the selected module have been analyzed with respect to price and both their advantages and disadvantages. This will definitely help in both performance evaluation and management strategies showing scopes of new vision of resources of an organization at present and future respectively.

8.4 Evaluate economic and financial aspects

The prototype version of our project is fully ready. It is working according to our expectations. Therefore, if we get some time, we can execute this project plan on our city bus. For that, we need a suitable fund. If our government, local bus transportation companies, or any related authority come to us for this project, we will help them to build this system. However, we will charge accordingly. To development this entire system in Dhaka city, multiple of these systems must be installed. In order to do that, various data is needed such as how many people living at a certain area (approximately), total numbers buses with respect to their routes, traffic data and common bus stop spots preferred by the public. If all such actions are taken then a successful system is ensured, thus managing it will be the main priority. To provide maximum customer satisfaction, the system can offer attractive services with discounts or similar activities.

To achieve the desired goal a prototype is implemented and has a certain budget.

Sl No.	Component	Price
1	Raspberry Pi 4 Computer (2GB)	5500
2	Raspberry Pi 7inch HDMI Touchscreen LCD with Case	4880
3	SIM900A GPRS GSM Module	1450
4	U-Blox NEO-6M GPS Module	845
5	ESP32-CAM WiFi + Bluetooth Camera	995
6	Arduino UNO R3 x2	1140
7	SG90 9G Micro Servo Motor x1	180
8	Laser DOT Diode x2	50
9	LDR x2	130
10	Antennas x2	798
11	Miscellaneous	1500
	Total	**17468**

Real implementation budget:

Sl No.	Component	Price
1	Raspberry Pi 4 Computer (2GB)	5500

2	Raspberry Pi 7inch HDMI Touchscreen LCD with Case	4880
3	SIM900A GPRS GSM Module	1450
4	U-Blox NEO-6M GPS Module	845
5	ESP32-CAM WiFi + Bluetooth Camera	995
6	Arduino UNO R3 x2	1140
7	SG90 9G Micro Servo Motor x1	180
8	Laser DOT Diode x2	50
9	LDR x2	130
10	Antennas x2	798
11	Hp Desk Jet Printer	3500
12	Miscellaneous	10532
	Total	30000

8.5 Conclusion

To sum it up, to develop a project not only performance of the system is enough but also economic view is compulsory since it allows a vision to be generated about the present and future of that project. This allows an estimation of resource consumption when a project is initialized and after implemented. Without such management, it becomes difficult to run the project.

Chapter 9: Ethics and Professional Responsibilities

9.1 Introduction

Whenever we are dealing with product that will be used by users in future a lot of things must be considered in order keep the user satisfied. If they are not then a bad impression is created for the manufacturer. So, to keep a stable impression a product must be designed in such a way that users will be always be given the highest priority. It is taken in such a way that even if there is a failure in consuming still they are placed in a soothing envirnment to maximum support.

9.2 Identify ethical issues and professional responsibility

- Using quality products.
- Payment Rules from Bangladesh Bank.
- User compensation for both payment and server issues.
- Several test cases to ensure safety.

9.3 Apply ethical issues and professional responsibility

Using cheap products can reduce the cost, but quality work should be maintained. So, we will take it very sincerely by performing mutiple test cases to verify safety. This is allow us to check if the desired output is being received or not. The procedure of ticket collecting is very comfortable with the digital payment system (Bkash/Nagad/Rocket) so that people can collect the ticket without having any cash money. As it is a smart bus stand, we are not considering cash. We will try to provide maximum satisfaction to the customer. We will ensure that every digital payment protocol of Bangladesh Bank will be maintained. Besides, a bank will help us to follow the correct rules and regulations of the payment method and taxes. In case of any failure in the payment system, the user will be compensated very quickly on the basis of the proper complaint. Additionally, we will take adequate security measures so that hackers are not able to break into our system easily. Finally, if our system freezes due to variation in load then we will comfort consumers to be patient and attempt to fix the problem immediately. Thus, we can provide less delay to solve and run any operation.

9.4 Conclusion

To sum it up, to design a certain product or services using engineering knowledge the main purpose is to keep the customers happy constantly. Thus, there must be zero tolerance about any fraud activities, which is later create a bad impression among consumers. Maximum support is ensured by comforting the customers perpetually.

Chapter 10: Conclusion and Future Work

10.1 Project summary/Conclusion

To sum it up, we completed our detailed multiple designs and found the optimal one which fulfills all the requirements, objectives, constraints and specific conditions. All designs have been tested for various cases to find their functionality and the optimal solution. Furthermore, relevant tools selection was performed to demonstrate the project in future. Afterwards, an updated project plan, contingency plan and budget has been introduced where we will divide the workload and responsibilities among ourselves. The optimal solution has been discussed in detail about ethical issues and some relevant impacts. Multiple test cases were performed at individual sub systems. There were some problem while implementing each components. Later on, after some analysis and research were done to receive our output. Finally, entire system is integrated using a PCB to manage cable. All references have been included in the report for the background surveys. Finally, we maintained a logbook to record every activity.

10.2 Future work

There are many things to be considered, as there is no limit for a better system. But all of them cannot be included using a prototype. So, some of the future works are given:

i. **Seat Choice Options.** (Provides the customer to select their desired seat locations.)

ii. **Dealing with uncooperative customers**. (If a customer does not follow the rules and regulations of the system. For example; Not getting off the seat after passing his/her desired location causing discomfort to new customer.)

iii. **Advanced Scheduling.** (Providing a Ticket Booking system.)

iv. **Student service.** (Providing half pass service for only student ID card verification.)

v. **Battery Backup System.** (Bus stand subsystem is by default designed to run on electric supply but in future, a backup battery is used to supply the entire system. The bus however does not need external battery as the bus provides an outlet to power every electric appliances.)

Chapter 11: Identification of Complex Engineering Problems and Activities.

11.1: Identify the attribute of complex engineering problem (EP)

Attributes of Complex Engineering Problems (EP)

	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	√

11.2: Provide reasoning how the project address selected attribute (EP)

Depth of knowledge:
To implement our project, we have gone through in-depth knowledge from both academics and published papers. With both of these background studies, we can follow a designed approach with a designed plan.

Range of conflicting:
To find the optimal design we went through satisfying various conditions. One of the conflicting requirements was convenient installation versus convenient use plus maintenance of some designs. Some design showed huge potential with rather high price. Moreover, there were conflicts while selecting the bandwidth characteristics versus the budget of some designs.

Depth of analysis:
We have done some depth analysis regarding budget, user convenience, maintenance, efficiency, sustainability and associated risks to find our optimal design from multiple designs. Finally, we found our best design to fulfill our purposes.

Familiarity of issues:
As Bangladesh is a developing country, so the absence of such optimized system common. However, in developed countries such a system is very common so, network interruption is a rare phenomenon. Since, networking issues is common in Bangladesh so, we were forced to select some certain components to make the system feasible.

Extent of applicable codes:

To complete the design in an organized manner, we have collected each applicable codes of specific components and services. We have collected them all trying to follow all of their rules and instructions. Furthermore, there are some applications, which were modified to our needs.

Extent of stakeholder involvement and needs:

Project's stakeholders are the people or groups who have something to gain or lose from the project's outcome.

Our project's name is "Smart Bus Stand System." The project is for the welfare of the city people. For example, we can think of Dhaka. The city is overpopulated. Therefore, it directly affects the transportation system. Besides, the public transportation system is itself not well organized. A smart bus stand system can be the possible solution. As the project is for the city people, we have many stakeholders.

Normally, there are two types of stakeholders. 1. Internal, 2. External.

Internal stakeholders:

Internal stakeholders are people or groups within the core team. For example, Project manager, team members, executives etc.

For our case: Project's team members, Faculty members, University etc.

External stakeholders:

External stakeholders are people or groups who are outside of the business. For example, customers, users, suppliers, and investors. In our case, general people are the main customer here. So, any user, suppliers (Electricity, Internet Provider), Government, BRTA, City Corporation. For any successful project, the roles of stakeholders are very important. For that, the project manager needs to be very careful about the day-to-day work. Some steps should be taken to make a successful project:

- Prioritizing the stakeholders
- Understanding the stakeholders
- Clear view about the roles of the stakeholders
- Proper communication with the stakeholders

Overall, we can say that it is teamwork. If communication & understanding is well defined and all the stakeholders can work properly being a team, a project can be successful.

Interdependence:

We have divided our project into 2 individual sub systems:

i.) Bus Stand.

ii.) Inside the Bus.

Furthermore, each section has been divided into multiple sections so that the load can be distributed with convenience.

11.3 Identify the attribute of complex engineering activities (EA)

Attributes of Complex Engineering Activities (EA)

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

11.4 Provide reasoning how the project address selected attribute (EA)

Range of resource:
In order to achieve our objectives, we are building a prototype were appropriate components needs to be taken under consideration. We purchased maximum components and some were borrowed from thesis lab of EEE department. After several research of components, we came to conclusion on budget. Furthermore, we did multiple analysis from various datasheets to find the optimal design.

Level of interaction:
To develop our solution, we needed to communicate and cooperate with many experts to obtain maximum support. All of their suggestions were generous to take initiatives at a constant rate.

Consequences for society and the environment:
As people want have a better living so, such a system will provide better services than before. Our system consists of common methods where it will not create discomfort while using it. If something goes wrong then regular compensation is enabled. Moreover, reduction environmental crowd is established.

Familiarity:
Since, most of bus stops signboard present are most of the time ignored so, people are always willing to take risks while getting into a running bus. Therefore, our project will ensure that the public does not take such risky actions. Furthermore, as our system is upgradeable with less cost so, maximum comfort is ensured for the passenger in future.

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Logbook:

Date	Attentee	Summary of Meeting	Responsible	Comment by ATC
14.10.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. EEE400C introduction class.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.
15.10.201	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Planing to implement two subsystems.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.
17.10.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Implementing ticket scanner using ESP32 cam scanner.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.
21.10.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. ATC meeting. 2. Feedback from our progress.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem. Task 2: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed. Task 2: Completed.
02.11.2021	1.MD Asif Imran Khan 2.Salamun Kawlam	1. Implementing GPS module and checking its range.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.

	3.Jannatul Nayeem 4.Rezwan UL Quadir			
10.11.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Implementing GSM module.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.
17.11.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Running the bus stand subsystem.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.
25.11.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Progress Presentation of demonstration.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 1: Completed.
05.12.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Started infrastructure construction using PVC. 2. Integration of subsystems.	Task 1: Jannatul Nayeem. Task 2: Rezwan, Imran, Salamun.	Task 1: Incomplete. Task 2: Incomplete.
20.12.2021	1.MD Asif Imran Khan 2.Salamun Kawlam	1. Started infrastructure construction using PVC. 2. Integration of subsystems.	Task 1: Jannatul Nayeem. Task 2: Rezwan, Imran, Salamun.	Task 1: Partially Completed. Task 2: Partially Completed.

	3.Jannatul Nayeem 4.Rezwan UL Quadir	3. Report writing.	Task 3: Rezwan, Imran, Salamun, Jannatul Nayeem.	Task 3: Partially Completed.
29.12.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Report writing. 2. Integration of subsystems. 3. Infrastructure construction using PVC.	Task 1: Rezwan, Imran, Salamun, Jannatul Nayeem. Task 2: Imran, Salamun Task 3: Jannatul Nayeem.	Task 1: Half Completed. Task 2: Half Completed. Task 3: Completed.
31.12.2021	1.MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4.Rezwan UL Quadir	1. Designing the PCB and ordering. 2. Report 3. Integration	Task 1: Imran, Salamun, Rezwan, Jannatul Nayeem. Task 2: Rezwan, Imran, Salamun, Jannatul Nayeem. Task 3: Imran, Salamun.	Task 1: Completed. Task 2: Half Completed. Task 3: Completed.
04.01.2022	1. MD Asif Imran Khan 2.Salamun Kawlam 3.Jannatul Nayeem 4. Rezwan UL Quadir	1. Report. 2. PCB received. 3. Draft presentation slide.	Task 1: Imran, Salamun, Rezwan, Jannatul Nayeem. Task 2: Imran, Jannatul Nayeem. Task 3: Completed.	Task 1: Completed. Task 2: Completed. Task 3: Completed.