Bus Fare Collection System Using RFID and GPS

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Abstract— **This paper discusses the development of an Automatic Fare Collection (AFC) combining the Radio Frequency Identification (RFID) and Global Positioning System (GPS) technologies for public transportation buses in Dhaka, Bangladesh. The paper begins with an introduction highlighting the need for such a system due to the dissatisfaction of passengers and high fare collection. A literature review is provided, presenting previous studies and systems using RFID and GPS technologies. The methodology section explains the working principle, components, implementation, and experimental setup of the proposed AFC system. The report then presents a cost analysis and discusses the results of the project, highlighting its limitations. The paper concludes with recommendations for future expansion of the project and references used in the report. The proposed system utilizes RFID and GPS technologies to record passenger boarding and arrival locations and automatically deduct fares. The system eliminates the need for paper tickets, offers onboard ticket inspection, and can introduce spatial validation elements to enhance its usefulness.**

Index Terms—**RFID, Ticketing system, GPS**

I. INTRODUCTION

Everything is intelligent and digitalized today, and the transportation industry has seen significant advancements. However, the public transportation buses in Dhaka have yet to keep up with these innovations. One area of research is intelligent transportation systems for people on the move, where the global positioning system plays a crucial role in determining positions. In some metropolitan areas where location determination errors may occur, visual odometry is another strategy that can be used. According to the BRTC government portal, there are 200 routes in Dhaka city [1], and 974 buses operate there [2]. Unfortunately, a survey conducted in March 2017 found that only 94 out of 995 respondents were satisfied with the bus services in Dhaka city, while 610 people were not satisfied [3]. Additionally, public transport has an additional fare collection of 182 Cr. taka per day.

The report is divided into several parts. The first part, Part I, provides an introduction to the report, including its purpose, how it was conducted, and the reason behind its creation. In Part II, a literature review is presented, which includes previous papers, data, analysis, and results related to the project. Part III explains the methodology of the report, outlining how the project was planned, the analysis that was conducted, the working principle, and a description of the components, implementation, and experimental setup. Part IV illustrates the cost analysis and describes how reliable the project is in terms of cost. In Part V, the report presents the results of the project, discussing how it helps in preventing fare collection problems and how it can change the entire experience of using local transport. The report also highlights its limitations. Part VI concludes the report and provides recommendations based on the results of the report, including future expansion of the project. Finally, Part VII provides references used in the report.

II. LITERATURE REVIEW

In [4] the RFID-based location information system not only assists in guiding passengers based on their present and intended destinations but also enables us to predict bus timings and offer a higher level of service. Alternatively, instead of using RFID and GPS, we can opt for smart cards to track passenger entry and exit locations and determine the fare by considering the distance covered during travel. The GPS and smart card can be connected to a microcontroller to program this system. [7]. Another research paper proposes a ticketing system that utilizes RFID-based tickets and GPS to calculate the fare and store the traveler’s information accurately. However, security concerns surround the reader's memory, which stores the passenger's transaction data for the entire day [5]. A different system that employs RFID tags to calculate the fare and maintaining the number of people boarding the vehicle requires additional time because only one tag can be scanned at a time [6].

III. METHODOLOGY

Buses are monitored by conductors who collect fares from passengers and distribute paper or token tickets. However, this method has its drawbacks. Conductors must ensure all passengers have tickets; printing tickets require more paper and time. Passengers must also keep their tickets until they reach their destination. To overcome these challenges, portable devices are now used. Nonetheless, this system can still be time-consuming and wasteful. For instance, if a passenger wants to board a bus, they must have cash, and the conductor will issue a ticket after collecting the money.

An alternative solution is the Automatic Fare Collection (AFC) system, which includes an automatic vehicle locating system that monitors every passenger boarding a bus and records transaction details such as the route, bus number, trip card used, and time and location of the journey. This system eliminates the need for paper tickets and can be used for onboard ticket inspection. Furthermore, it can introduce novel spatial validation elements to enhance its usefulness.

A. RFID system

The system consists of three primary components, namely an antenna, a RFID tag, and a transceiver. These components are illustrated in Figure 1. A key benefit of RFID technology, unlike other systems, Line of Sight (LOS) scanning is not required. When the antenna sends a signal to the transponder using radio frequency waves, it activates the transponder. Once activated, the antenna can receive data that the tag transmits. This data is then used to notify a programmable logic controller to detect any action. The actions detected can be simple, like opening a gate, or complex, like interacting with a database to conduct a financial transaction.

RFID systems that operate between 30 KHz and 500 KHz can typically only cover short distances of less than six feet, while higher frequency systems that operate between 850 and 950 MHz and between 2.4 and 2.5 GHz can cover longer distances of over 90 feet. In general, as the frequency increases, the cost of the system also increases.

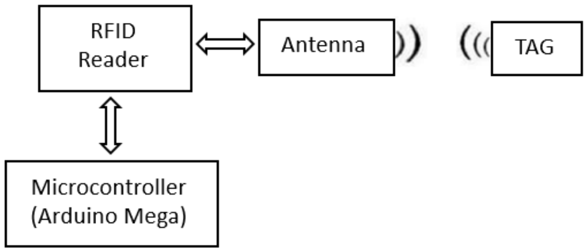

Fig. 1. RFID System.

B. GPS System

GPS is a radio signal-based system that determines a user's location and provides features such as moving-map displays and GPS-enabled radio controls, also available from car manufacturers. The GPS receiver can compute a vehicle's position in terms of latitude and longitude.

C. Process

Passengers tap their card on an RFID reader when they board the bus, and the Arduino saves their departure location against their card ID. When the passengers reach their destination, they tap their card again, and the arrival location is recorded. The distance traveled is calculated, and the fare is automatically deducted.

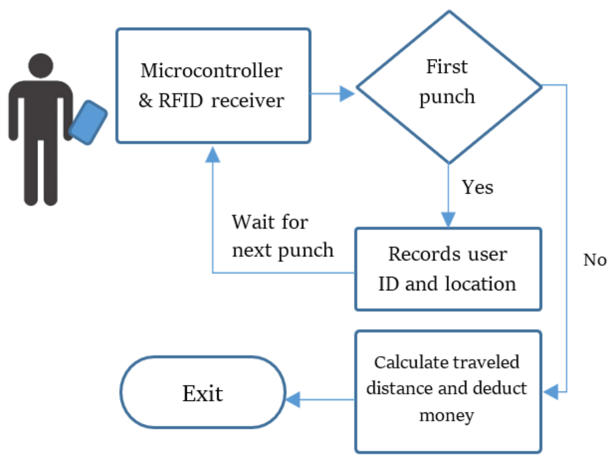

Fig. 2. Project workflow.

D. Components

The ATmega2560-based microcontroller board, known as the Arduino Mega 2560, contains 54 digital input/output pins, of which 15 can function as PWM outputs. Additionally, it has 16 analog inputs, 4 UARTs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

Fig. 3. Arduino MEGA.

The RFID reader is a device that can be connected to a network and is either portable or fixed. It employs radio waves to send signals that trigger the tag. Once the tag is activated, it emits a wave received by the antenna and then translated into data. The transponder is located within the RFID tag.

Fig. 4. RFID Reader.

The GPS relies on signals from satellites in space and Earth-based ground stations to accurately determine its location on Earth. The NEO-6M GPS receiver module operates USART communication to connect to an Arduino or PC interface.

Fig. 5. GPS Module.

The LCD can show 16 characters per line, and two lines are available. A 5x7 pixel matrix represents each character. The 16x2 alphanumeric dot matrix display can exhibit 224 various characters and symbols. The LCD is equipped with two registers, which are Command and Data.

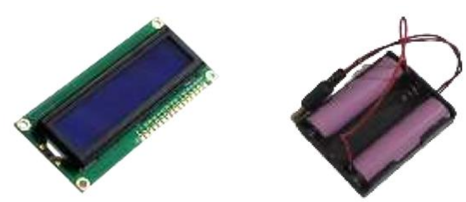

Fig. 6. 16x2 LCD and 3.7v x 2 battery with DC jack.

Fig. 7. Breadboard and Jumper Wires.

Fig. 8. Green led, Red led and 330Ohm resistor.

E. Implementation

In this project Arduino Mega acts as mater and other module acts as slave. RFID reader, GPS module, LCD 16x2 is slave. So, this module is connected according to particular module datasheet. After warring all component accordingly, we run some example code to test each module. Connection between Arduino mega to other modules, battery and LEDs.

RFID Reader	**Arduino Mega**
RST	5
SDA (SS)	53
MOSI	51
MISO	50
SCK	52
3.3v	3.3v
GND	GND

LCD Display	**Arduino Mega**
GND	GND
VCC	5v
SDA	SDA
SCL	SCL

GPS Module	**Arduino Mega**
GND	GND
VCC	3.3v
RX	RX1
TX	TX1
Green led 1	6
Red led	7
Green led 2	8
3.7v x 2 battery	DC input

F. Experimental Setup

According to implementation setup all module has been connected, here is the connection picture.

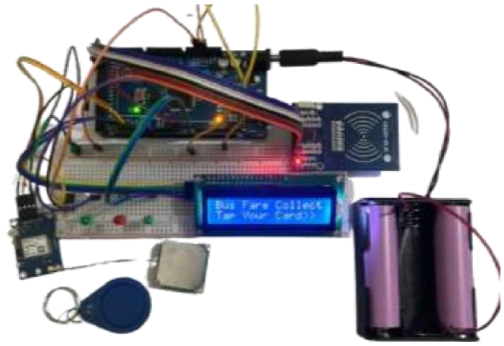

Fig. 9. Experimental setup of bus fare collection system.

IV. Results And Discussion

A. Actual implementation and result

Showing step by step how this project runs. In idle state RFID reader ready to scan RFID tag or card. LCD display shows project title and gives instruction to tap your card.

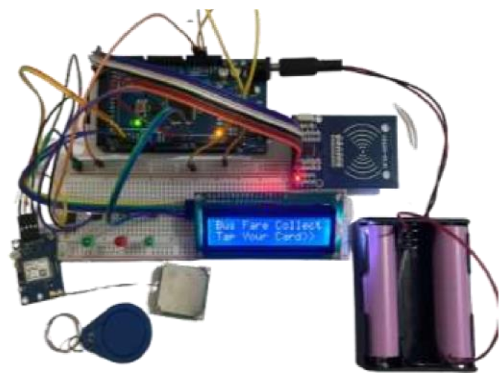

Fig. 11. Project in idle state.

Upon the first card punch by a passenger, the Arduino device saves the RFID tag data along with the latitude and longitude of the location for future reference. This enables the Arduino to calculate the distance between the first and second punch locations when the same passenger punches the card again. The RFID reader remains in an idle state and is always ready to scan the RFID tag or card. The LCD display showcases the project title and provides instructions for the passenger to tap their card.

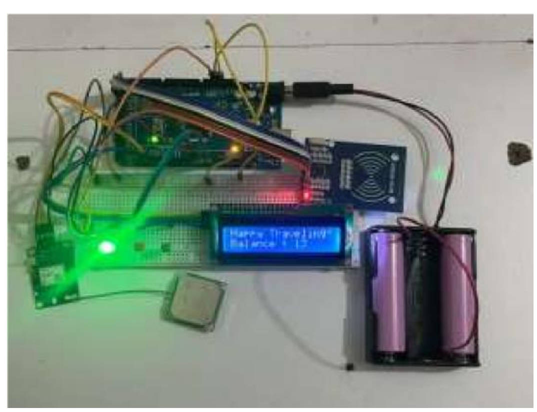

Fig. 12. Passenger punch the RFID tag/card.

In second punch Arduino first compere it's new punch or second punch. If it is second punch Arduino takes current location and calculates distance form previously stored location. Arduino also calculate fare according to the distance.

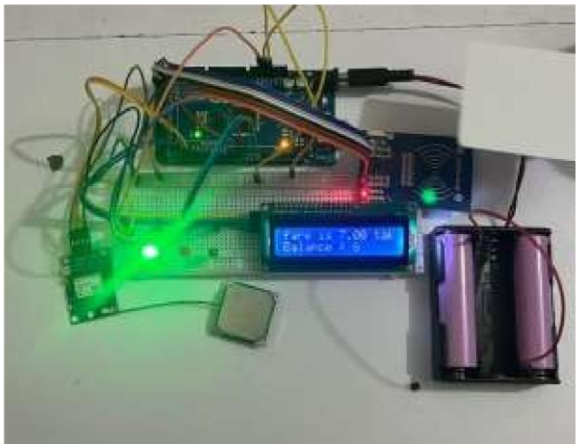

Fig. 13. Passenger punching again and fare deducted.

Using blue RFID tag this turns into recharge mode, now punching passenger card will recharge 40 points.

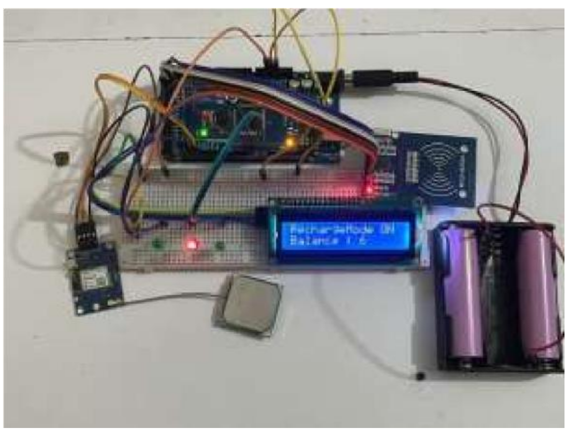

Fig. 14. Recharge mode on.

After recharge it shows success message and balance.

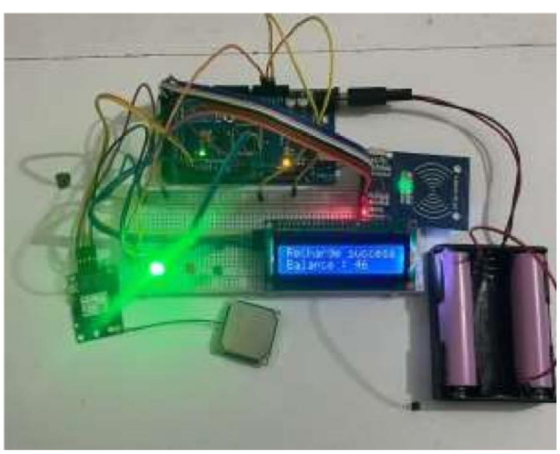

Fig. 15. Recharge Success.

When balance is low it will not allow to travel, shows balance low message and current balance. Also indicate a red led.

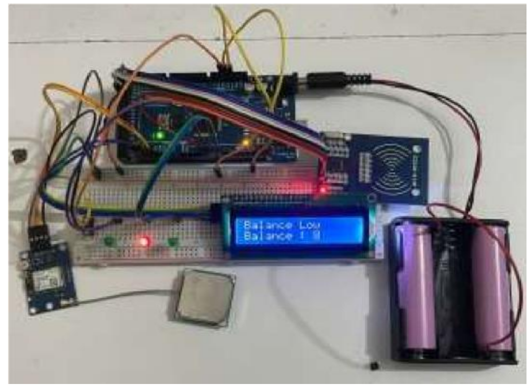

Fig. 16. Balance low.

Therefore, explaining all functionality of this project, it serves the basis solution of our problem. It works accurately as our model and expectation.

B. Limitations in the project

- This project can't handle new user, project only works for the given RFID tag in the implementation code.
- GPS doesn't work in indoor. So, we used time function to calculate fare.

V. CONCLUSION

The proposed solution smooths the ticketing process by replacing paper tickets, reducing ticket processing time, and avoiding unnecessary disputes between passengers and ticket inspectors. The travel card enables users to exchange tickets with exact change and eliminates needing to renew bus passes at the transportation company in person. Additionally, this project has the potential for future expansion, including developing an app that enables users to track their bus's exact location and complete transactions using credit cards and mobile banking payment channels. To prevent the fraudulent use of a lost or stolen travel card, it is necessary to include a feature to deactivate the card. This travel card will tackle the typical problems experienced by commuters and ticket inspectors by integrating modern features, while also helping the transportation company to boost their revenue. With the implementation of this system, the actual fare collection will be ensured, eliminating any possibility of extra charges. Additionally, the system will also ensure that students receive discounted fares.

VII. REFERENCES

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