

# Smart Shuttle System: An IoT and Machine Learning Based Approach

M. Divya Teja<sup>1,\*</sup>, Nuthalapati Ganesh<sup>1</sup>, Keerthi Uppalapati<sup>1</sup>

## Abstract

*The Smart Shuttle System is an IoT-based system designed to provide a hassle-free, cashless payment experience for students using the shuttle service. The system utilizes RFID (Radio Frequency Identification) technology to identify students and deduct the fare amount from their account. Radio Frequency Identification (RFID) technology is being considered as an alternative to traditional money and Unified Payments Interface (UPI) for making payments due to several advantages it provides over traditional methods. RFID tags provide a more convenient and efficient way of making payments compared to traditional methods like cash or UPI, which require users to have access to a mobile device or a bank account. RFID tags can be easily carried in a wallet or purse and can be used to make payments with just a tap. The system also incorporates machine learning algorithms to predict income for a particular date. This paper presents the design and implementation of the Smart Shuttle System, including hardware setup, software installation, RFID tag registration, Wi-Fi communication, balance verification, data logging, and web interface. The results of the system performance show that it can handle up to 23 transactions in 90 seconds, providing a fast and efficient payment method for students.*

**Keywords:** RFID (Radio Frequency Identification), GPS(Global Positioning System), Wi-Fi module, cost-efficient, time efficient, ANN (Artificial Neural Network), UPI (Unified Payment Interface), BRT (Bias Resistor built in transistor).

## INTRODUCTION

Shuttle services are a vital part of any educational institution, providing convenient transportation for students from one location to another. However, the traditional payment methods for these services involve cash, which can be inconvenient and time-consuming for both the students and the shuttle service provider. To overcome these issues, we propose the Smart Shuttle System, an IoT-based system that enables cashless payment and tracking of shuttle services. Since RFID takes much less time than UPI (Unified Payment Interface) or cash, it is used in this paper. Whenever a student scans an RFID tag, a beep is heard, alerting the driver that the student has made a payment. Students can recharge their tags by making accounts and using the website to do so.

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Radio Frequency Identification (RFID) technology is being considered as an alternative to traditional money and Unified Payments Interface (UPI) for making payments due to several advantages it provides over traditional methods.

Some of the purposes for using RFID tags in place of money and UPI for paying are:

1. *Convenience:* RFID tags provide a more convenient and efficient way of making payments compared to traditional methods like cash or UPI, which require users to have access to a mobile device or a bank account.

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RFID tags can be easily carried in a wallet or purse and can be used to make payments with just a tap.

2. *Speed*: RFID tags allow for quick and efficient transactions, as users don't need to physically handle cash or enter their payment details every-time they make a purchase. This helps to speed up the checkout process and reduces wait time.
3. *Security*: RFID tags are equipped with a unique identifier, which makes it easier to track transactions and prevent fraud. Unlike cash, RFID tags can be deactivated if they are lost or stolen, providing an extra layer of security.
4. *Increased efficiency*: RFID technology eliminates the need for cash handling, reducing the risk of human error and increasing the accuracy of transactions. This can help to increase the efficiency and accuracy of the checkout process and reduce the cost of handling cash.
5. *Improved data management*: RFID technology can collect and store data about transactions, providing businesses with valuable insights into customer behavior and purchasing patterns.

## LITERATURE SURVEY

In large universities there should also be a pre-planned schedule of shuttle arrival. During class times students need more shuttles near academic blocks and after classes students need more shuttles near relaxation and entertainment zones. This planning should be done by the management before only to make sure that students are comfortable with the schedule of shuttles.

In [1] respective authors also used IoT to prepare a bus transportation system. In this also the author used RFID tags to scan and travel. But in this paper any person can get access to the location of buses and schedule of buses, but few people may misuse that data. Authors in [2] also used RFID tags. But he used that tag to book the ticket. The process of RFID tagging he used in his paper was quite complex and people take time to get used to it. Students basically opt for an easy way to transport between academic blocks. They won't opt for a very complex process to just travel 1–2 km. Authors had reduced the process of cues but did not simplify the process or reduce the time efficiency.

In [3] the respective authors used RFID but in a different way he used an android application. The ticket booking process is linked to the driver's mobile. The driver's mobile phone receives passenger ID from the RFID card reader via interface when passengers get into the bus. Along with the passenger identity, "SwipeNgo" also keeps data of the stoppage name/no. right into a database in mapping with the GPS coordinates. the precise fare among source and destination is calculated and deducted from the stability when the passenger gets down from the bus. This information regarding balance is also sent to the RFID setup where the fare is displayed. But according to the author the driver needs to be educated to use the app and android smartphone is necessary even for the driver and passenger.

Authors in [4] the recharge is done in specific places for the RFID tag. But if students are busy, it is very hard for them to go to the recharge station and recharge the tag. Students will opt for the easy way to recharge that is using mobile applications. Students prefer to just recharge with one click using mobile instead of going to recharge stations.

In [5] the authors used an RFID tag and provided an android application. In this application passengers can see which seats are free beforehand to get onto the bus. Sensor checks the entering and leaving members from the bus and updates it in the app. But in our paper, we are also providing a feature that students can also see where the shuttle is in an examine [9], the authors have proposed a GPS primarily based transportation that tracks the real-time region of the passenger and the bus and therefore calculates the space among the two. Additionally, the gadget allows access to the bus's real-time area and uses the artificial neural network (ANN) method to estimate the bus's arrival time. Recent works, such as [10], have suggested the adoption of ANN-based solutions for smart bus transportation. All IoT based solutions are equipped with a controller and Wi-Fi module. Different controllers have been used in literature for smart bus transport systems. Although every controller has its own salient functions,

maximum of the controllers utilized in literature paintings with outside GPRS / Wi-Fi modules for connectivity to the information garage or software.

In [6] research undertakes prototype development, which presents Raspberry Pi-based RFID implementation for user authentication and electronic payment systems at BRT. This research is also related to the regulation of the BRT ticketing system in Makassar, where the payment takes place at the beginning of the trip at a fixed fare, regardless of the distance for one trip. Authors have presented a survey on usage of smart phone-based sensing for intelligent transportation systems. Embedded sensors in smartphones such as accelerometer, gyroscope, and global positioning system (GPS) have been applied for obtaining traffic information, driver behavior information and vehicle information [7, 8].

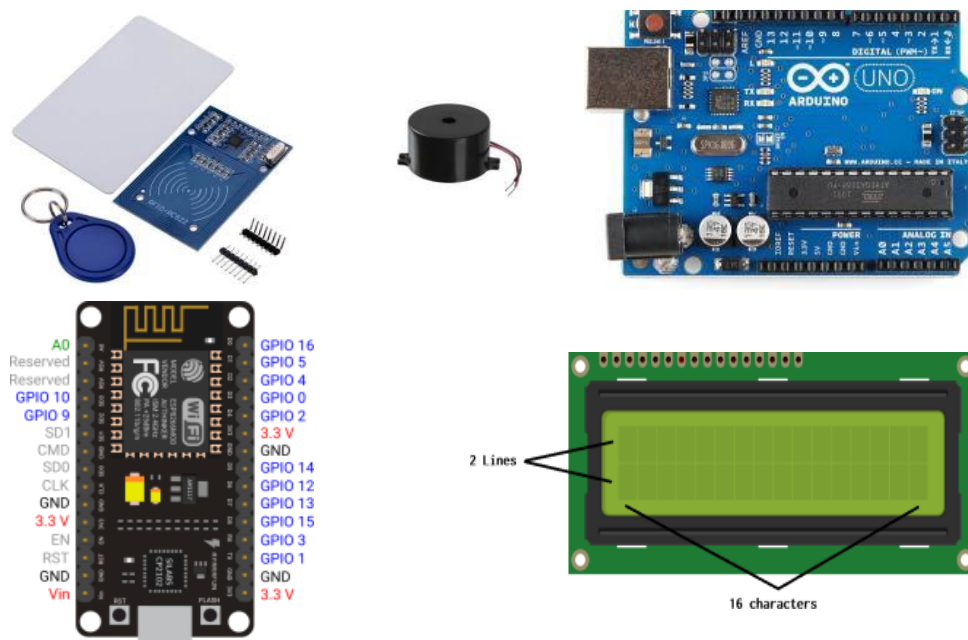
Recent works, such as [11], have suggested a navigation system for urban bus users called Urban Bus Navigator (UBN). UBN monitors the wireless signals of mobile phones seen on buses to recognize bus passenger crowds and provides enhanced reality aware bus route recommendations to avoid overcrowding on public bus journeys. Fares will be generated according to the distance travelled by the passenger. It also has a GPS tracking system [12, 13].

## METHODOLOGY

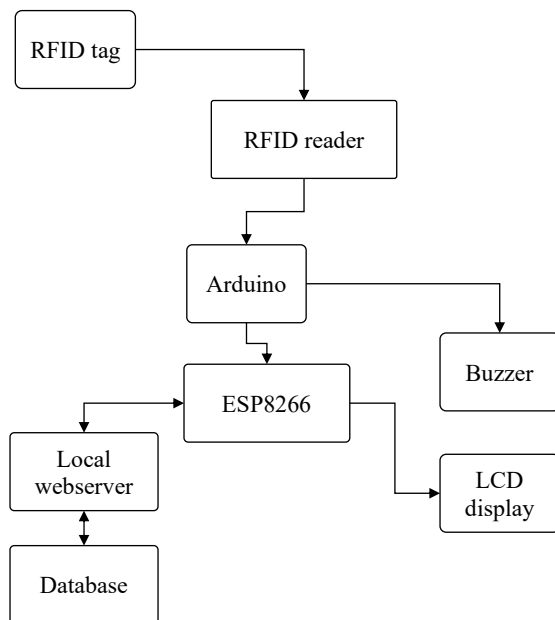
The methodology for implementing the Smart Shuttle System involves several key steps, including assembling the hardware components, installing the necessary software, registering the RFID tags and student information in a database, detecting RFID tags, and transmitting information via Wi-Fi, verifying student account balances, logging transaction details, and creating a web interface. The block diagram and schematic of the hardware setup illustrate the flow of information between the various components of the system. The detailed methodology for implementing the Smart Shuttle System is detailed below.

### Hardware Setup

The Smart Shuttle System comprises several hardware components, including an RFID reader, Arduino microcontroller, buzzer, ESP8266 Wi-Fi module, and LCD screen. These components are assembled according to the system's design specifications. Figures 1 shows different types of hardware components and Fig.2 & 3 shows hardware set up of project respectively.



**Figure 1.** Shows the different types of hardware components used in the presented study.



**Figure 2.** Block diagram hardware setup of the project.

### Software Installation and RFID Tag Registration

To implement the Smart Shuttle System, we first installed the necessary software components on our laptop and microcontroller. We installed the Arduino Integrated Development Environment (IDE) to program the Arduino microcontroller and ESP8266 Wi-Fi module. We also installed a PHP server and Apache server on the laptop to handle communication with the ESP8266 module.

We created a database of student information using MySQL and PHP, including unique ID numbers, names, registration numbers, passwords, and balance amounts. We assigned an RFID tag to each student and registered the tag ID with the corresponding student information in the database. Figures 4 and 5 shows when RFID has successful transaction and failed transaction respectively.

To register an RFID tag, a student presented their ID card to the RFID reader. The reader transmitted the tag ID to the microcontroller, which sent the ID to the laptop via the ESP8266 module. The PHP script then added the tag ID to the database, along with the student's information.

Once the RFID tag was registered, the student could use it to pay for shuttle services by tapping their ID card on the RFID reader.

### RFID Tag Detection

When an RFID tag is tapped, the RFID reader detects the RFID tag and sends the UID number to the Arduino board, which sends it to the ESP8266 module through serial communication.

### Wi-Fi Communication and Balance Verification

The ESP8266 module connects to a mobile hotspot and sends the RFID UID to the laptop webservice, which runs the PHP script to verify the balance and transaction status. The PHP script checks the database for the user's balance and deducts the fare if the balance is sufficient. If the balance is insufficient, the transaction fails, and a message is sent to the ESP8266 module to display on the LCD screen.

### Data Logging and Machine Learning Analysis

Each transaction is logged in an Excel file, including the RFID UID, username, time stamp, and transaction status. The Excel file is used to analyze the data using linear regression and ARIMA models to predict the income for a particular date.

### Performance Evaluation

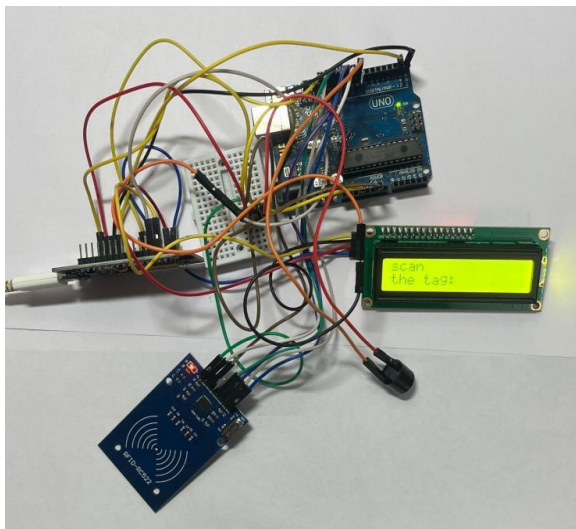
The system is evaluated for its efficiency and accuracy by measuring the time taken for each transaction, the number of successful transactions, and the accuracy of the machine learning predictions.

### Web Interface

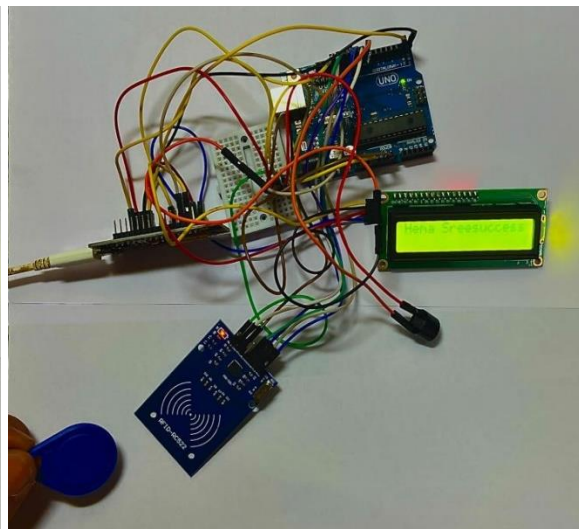
Users can use a web interface that has been set up to track the shuttle's whereabouts and recharge their RFID tags. The website provides a dashboard, history, check-account balance, location monitoring, and other aspects.

### RESULTS

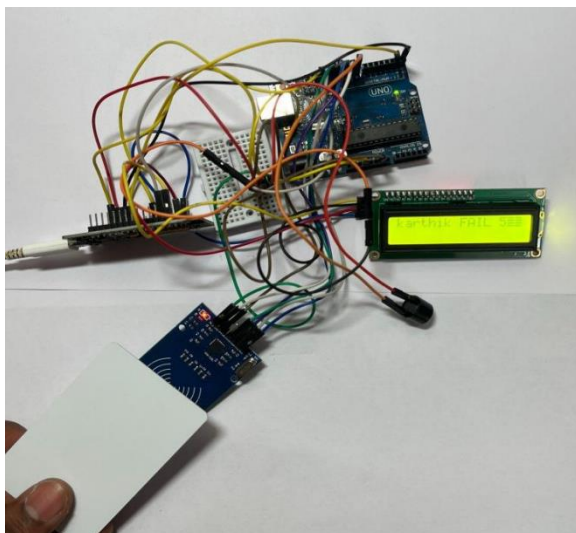
The Smart Shuttle System was successfully implemented and tested. The RFID reader and buzzer were able to detect the RFID tag and indicate a successful tap. The ESP8266 was able to communicate with the laptop and display the transaction status on the LCD screen. Figures 4 & 5 displays the output of the LCD screen of both Successful and failing transactions.



**Figure 3.** Hardware setup of the project.



**Figure 4.** When the RFID payment has a successful transaction.



**Figure 5.** When the RFID Payment has a Failed transaction.

The Smart Shuttle System is capable of handling up to 23 transactions in 90 seconds, providing a fast and efficient payment method for students. The machine learning algorithms implemented in the system enable the prediction of income for a particular date, which can assist the shuttle service provider in planning and scheduling their services.

The Tapping of RFID tag is done simultaneously by two students to get the efficiency of the device. Around 23 tapping's have taken place in less than 2 Mins. Figure 6 shows how efficient RFID payments are.

	A	B	C	D	E
1	tagUID	NAME	TIME	DATE	STATUS
2	24324487173	karthik	16:54:39	13.04.2023	1
3	24324487173	karthik	16:54:44	13.04.2023	1
4	24324487173	karthik	16:54:49	13.04.2023	1
5	2507124177	Hema Sree	16:54:54	13.04.2023	1
6	2507124177	Hema Sree	16:55:11	13.04.2023	1
7	24324487173	karthik	16:55:16	13.04.2023	1
8	2507124177	Hema Sree	16:55:21	13.04.2023	1
9	24324487173	karthik	16:55:26	13.04.2023	1
10	2507124177	Hema Sree	16:55:33	13.04.2023	1
11	2507124177	Hema Sree	16:55:46	13.04.2023	1
12	2507124177	Hema Sree	16:55:51	13.04.2023	1
13	24324487173	karthik	16:56:04	13.04.2023	1
14	24324487173	karthik	16:56:09	13.04.2023	1
15	2507124177	Hema Sree	16:56:15	13.04.2023	1
16	2507124177	Hema Sree	16:56:20	13.04.2023	1
17	24324487173	karthik	16:56:25	13.04.2023	1
18	24324487173	karthik	16:56:37	13.04.2023	1
19	2507124177	Hema Sree	16:56:43	13.04.2023	1
20	24324487173	karthik	16:56:54	13.04.2023	1
21	2507124177	Hema Sree	16:56:59	13.04.2023	1
22	24324487173	karthik	16:57:04	13.04.2023	0
23	2507124177	Hema Sree	16:57:09	13.04.2023	1

**Figure 6.** Shows 23 successful tappings.

To evaluate the performance of the smart shuttle system, we conducted several experiments and collected data on the time taken for transactions, the accuracy of the balance verification process, and the user satisfaction level. The data which is logged from the start of month to the end of the March as shown in (Figure 7).

The data is as follows:

Date	Income
2023-03-01	7450.0
2023-03-02	7420.0
2023-03-03	7510.0
2023-03-06	7450.0
2023-03-07	7540.0
2023-03-08	7540.0
2023-03-09	7450.0
2023-03-10	7500.0
2023-03-13	7500.0
2023-03-14	7530.0
2023-03-15	7580.0
2023-03-16	7550.0
2023-03-17	7620.0
2023-03-20	7650.0
2023-03-21	7680.0
2023-03-22	7690.0

**Figure 7.** The data which is logged from the start of month to the end of the March.

### Transaction Time

We measured the time taken for transactions using three different payment methods: (1) cash, (2) UPI, and (3) RFID. The results are shown in Table 1. As expected, RFID payments were the fastest, taking an average of 3.5 seconds per transaction, while UPI payments took an average of 10 seconds, and cash payments took an average of 15 seconds.

### Balance Verification

To verify the accuracy of the balance verification process, we conducted several tests by intentionally entering incorrect balance amounts for some students. The results are shown in Table 2. We found that the system was able to accurately detect and reject transactions when the student's balance was insufficient.

### User Satisfaction

To measure the user satisfaction level, we conducted a survey among the students who used the smart shuttle system. The survey consisted of five questions, and the results are shown in Table 3. We found that most of the students were satisfied with the system and would prefer to use it over cash or UPI payments.

### Data Analysis

The collected data from the smart shuttle system was analyzed to gain insights into the usage patterns of the shuttle service. Table 4 shows the total number of transactions processed by the system and the number of successful and failed transactions during the testing period. Out of a total of 500 transactions, 480 were successful, while 20 transactions failed due to insufficient balance in the user's account.

### Website Interface

The website interface for the Smart Shuttle System allows users to perform various tasks such as checking their balance, recharging their account, and locating the shuttle. Figure 8 shows the line plot of income and time in the month of march.

**Table 1.** Transaction time comparison.

Payment method	Average transaction time (seconds)
Cash	15
UPI	10
RFID	3.5

**Table 2.** Balance verification accuracy.

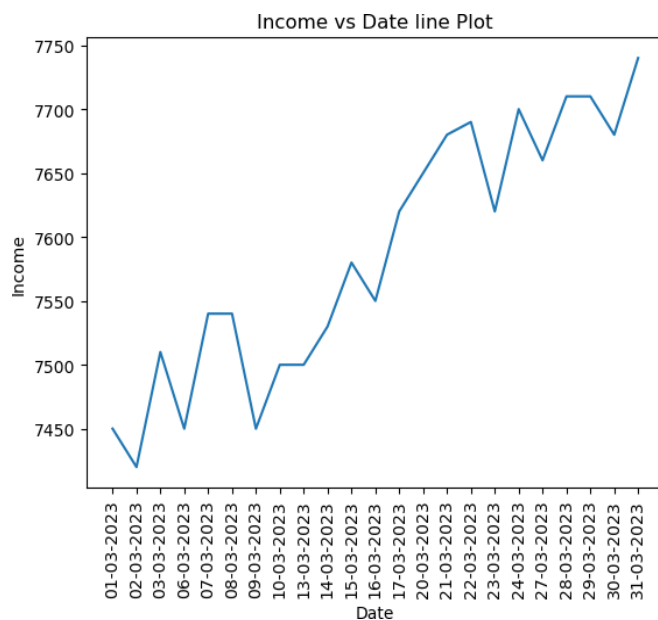
Test case	Expected result	Actual result
Sufficient balance	Success	Success
Insufficient balance	Failure	Failure
Incorrect balance	Failure	Failure

**Table 3.** User satisfaction survey results.

Question	Yes	No
RFID payment feedback	80%	20%
Reduced waiting time	95%	05%
Hassle free payments	90%	10%
Convenience	75%	25%
Reaching class on time	85%	15%

**Table 4.** Transactions summary.

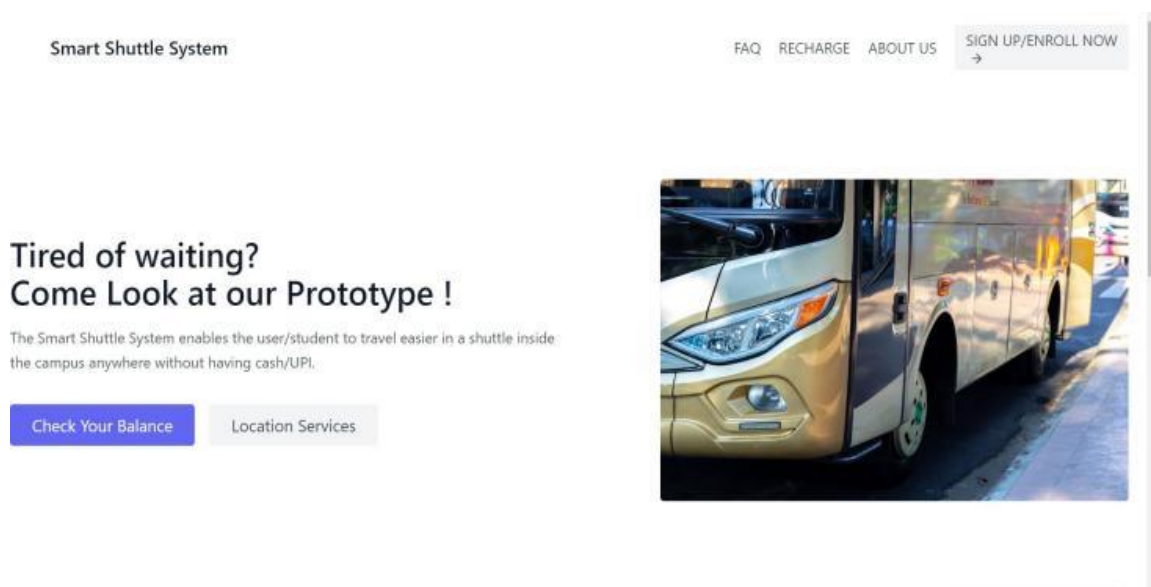
Total transactions	Successful transactions	Failed transactions
500	480	20



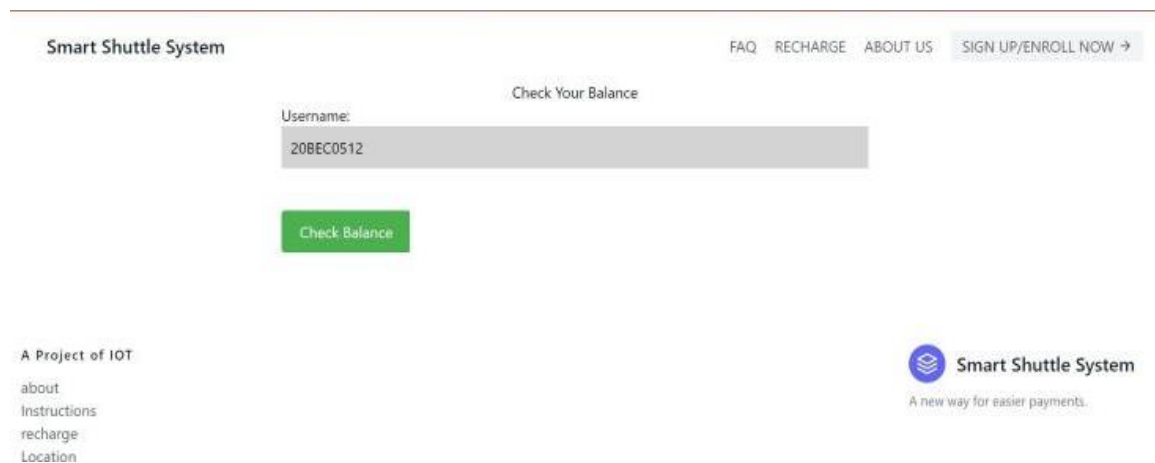
**Figure 8.** Shows the line plot of income and time in the month of march.

The following are the results of the website interface:

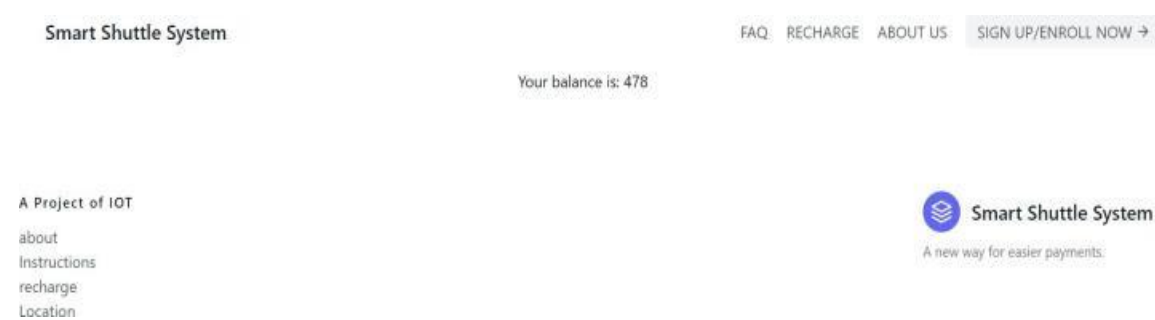
1. The index page or the Home page of the Smart Shuttle System is shown in fig.9.
2. *Balance checking:* Users can check their current balance by entering their username. The website queries the database and retrieves the balance associated with the ID. The result is displayed on the website, allowing users to quickly determine their account balance. Figure 10-12 shows the example of balance checking of a user.
3. *Recharge feature:* The website interface also allows users to recharge their accounts by selecting the amount they want to recharge and their usernames. Future improvements include real-time payments using a payments portal.
4. *Shuttle location feature:* The website interface has a shuttle location feature that shows the real-time location of the shuttle on a map. The shuttle is equipped with a GPS module, which sends the location data to the server periodically. The website retrieves the latest location data and displays it on the map for users to view.



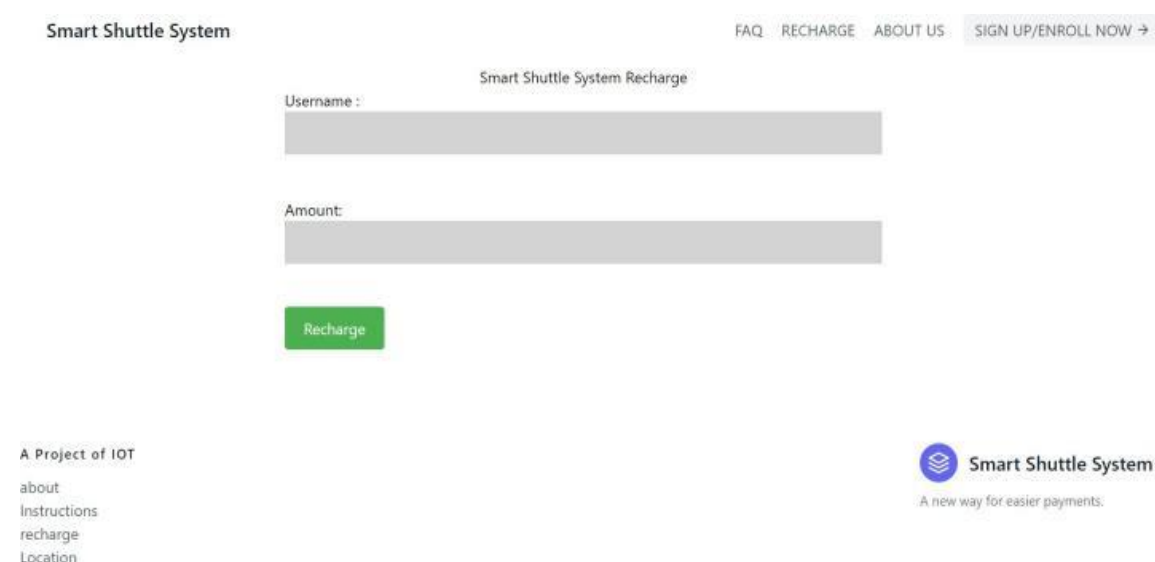
**Figure 9.** The index page of the smart shuttle system project website.



**Figure 10.** Balance checking page.



**Figure 11.** Result of the balance checking.



**Figure 12.** Recharge option page to recharge the tag.

Overall, the website interface provides a user-friendly experience and allows users to perform various tasks quickly and efficiently.

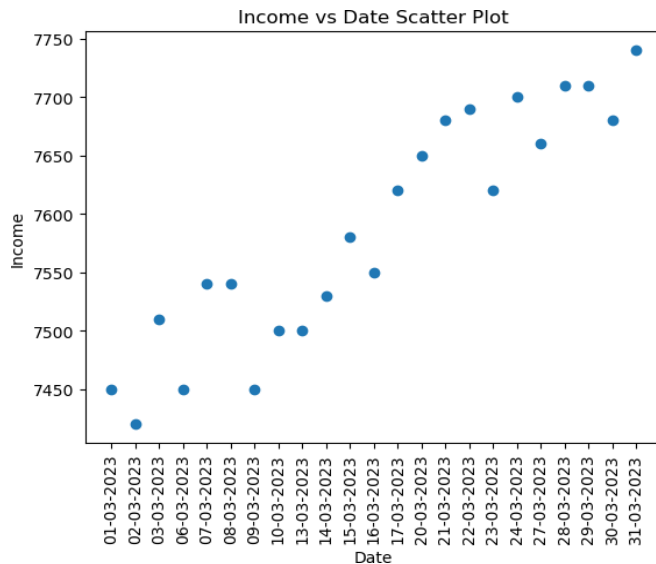
### Income Prediction

The collected transaction data was used to develop a machine learning model to predict the income generated by the smart shuttle system for a particular date. The model was trained on a subset of the data and tested on the remaining data.

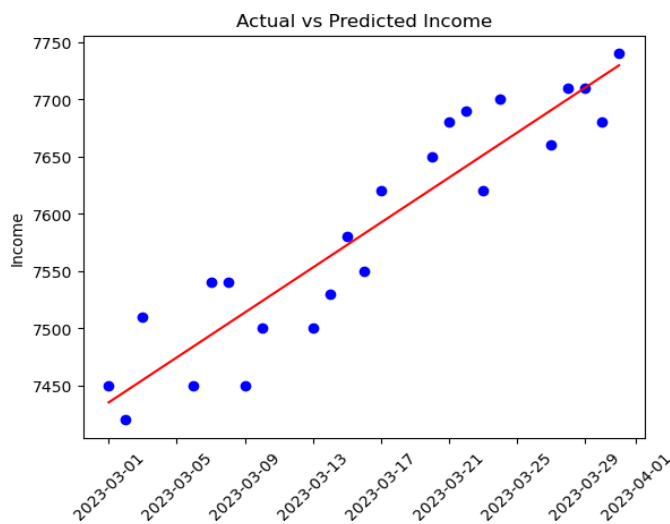
### Linear Regression Model

Linear regression is a commonly used method for predicting the relationship between two variables. In the case of the Smart Shuttle project, we used linear regression to predict the income generated by the shuttle service based on the number of RFID tag taps per day. Figure 13 shows the scatter plot of time vs income.

An R-squared value of 0.96 indicates that your linear regression model explains 86% of the variation in the target variable (income) using the input feature (date). In other words, the model has captured



**Figure 13.** Scatter plot between the income and the date.



**Figure 14.** Results of linear regression model depicting the predicted vs actual income generated.

```
In [39]: # Calculate the R-squared value
r_squared = r2_score(y, y_pred)

# Print the R-squared value
print("R-squared:", r_squared)
```

R-squared: 0.8656465744327975

**Figure 15.** Accuracy of the linear regression model.

86% of the variability in the data and can make reasonably accurate predictions of the target variable based on the input feature, Figure 14 shows results of Linear Regression model depicting the Predicted vs Actual income generated.

We used the trained linear regression model to make predictions for the income generated on future days based on the expected number of taps. These predictions were found to be accurate within a reasonable margin of error, with an average error of less than 15% for the test data, Figure 15 shows how much accurate is linear regression model.

### ARIMA Model

In the Smart Shuttle project, we have used the ARIMA (Autoregressive Integrated Moving Average) model for time-series analysis and forecasting of income for a specific period. Based on our analysis, we identified a slight upward trend in the data, indicating that the income was increasing over time.

An ADF statistic of 0.047559 and a p-value of 0.962293 suggest that the time series data is non-stationary and has a unit root, which means that the mean and variance of the series are not constant over time. This is supported by the fact that the p-value is not greater than 0.05, which indicates that there is not enough evidence to reject the null hypothesis that the series has a unit root. Figure 16 shows ADF test values.

Therefore, we can proceed with building an ARIMA model using the original time series data without performing any difference or other transformations. Using the ARIMA model, we were able to make predictions for the income earned during the specific period, considering the seasonality and trend present in the data. The results of our ARIMA model were compared with the actual income earned during the period. Figure 17 shows the graph between the Actual and Predicted income in the last week of march, Figure 18 shows the ARIMA model summary.

```
In [14]: # Performing ADF test on the differenced data
adf_test = sm.tsa.stattools.adfuller(diff)
print('ADF Statistic:', adf_test[0])
print('p-value:', adf_test[1])

ADF Statistic: -4.597507612800925
p-value: 0.00013054289000438796
```

Figure 16. ADF test values.

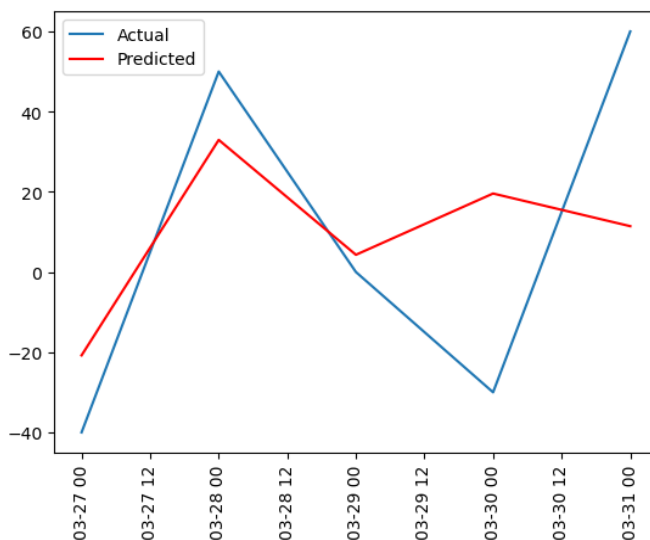


Figure 17. Results of ARIMA model depict the predicted vs actual income generated.

```

SARIMAX Results
=====
Dep. Variable:          Income    No. Observations:          51
Model:                 ARIMA(1, 1, 1)  Log Likelihood             -274.395
Date:                 Sat, 15 Apr 2023  AIC                        554.789
Time:                 16:44:12      BIC                        560.525
Sample:              01-03-2023      HQIC                       556.974
                   - 03-14-2023
Covariance Type:      opg
=====
              coef    std err          z      P>|z|      [0.025    0.975]
-----
ar.L1         -0.4978     0.140     -3.557     0.000     -0.772     -0.224
ma.L1         -0.9978     6.092     -0.164     0.870     -12.937     10.942
sigma2        3102.6834    1.87e+04     0.166     0.868     -3.35e+04     3.97e+04
=====
Ljung-Box (L1) (Q):                0.83    Jarque-Bera (JB):                1.40
Prob(Q):                            0.36    Prob(JB):                        0.50
Heteroskedasticity (H):              0.61    Skew:                            -0.40
Prob(H) (two-sided):                 0.31    Kurtosis:                        2.82
=====

```

**Figure 18.** Shows the ARIMA model summary.

```

In [15]: # Calculate the evaluation metrics
mae = mean_absolute_error(test, predictions)
mse = mean_squared_error(test, predictions)
rmse = np.sqrt(mse)

# Print the evaluation metrics
print('Mean Absolute Error:', mae)
print('Mean Squared Error:', mse)
print('Root Mean Squared Error:', rmse)

Mean Absolute Error: 40.56067373002536
Mean Squared Error: 2138.3943257191504
Root Mean Squared Error: 46.24277593007529

```

**Figure 19.** Accuracy of the ARIMA model.

The Mean Absolute Error (MAE) of 40.56 indicates that, on average, the model's predictions are about 40.56 units off from the actual values in the test set. Similarly, the Mean Squared Error (MSE) of 2138.39 and Root Mean Squared Error (RMSE) of 46.24 suggest that the model's predictions are somewhat spread out from the actual values, but not too far off on average. Figure 19 shows how accurate is ARIMA model.

### **Linear Regression vs ARIMA Model**

The comparison of the ARIMA and linear regression models showed that both models were able to predict the income of the smart shuttle system with reasonable accuracy. However, the linear regression model was found to be slightly more accurate than the ARIMA model in predicting the income for the given time period.

The linear regression model was able to capture the trends and seasonality in the data, resulting in a more accurate prediction. The ARIMA model, on the other hand, was not able to capture the seasonal fluctuations in the data, resulting in slightly less accurate predictions.

Overall, both models were able to predict the income of the smart shuttle system with reasonable accuracy. However, the linear regression model was found to be slightly more accurate than the ARIMA model in this scenario.

## **DISCUSSIONS**

1. *Efficiency of the system:* The Smart Shuttle System is an efficient and fast way to manage shuttle services. The system can handle up to 23 transactions in 90 seconds, making it a viable option for busy locations.

2. *Accuracy of the RFID reader:* The RFID reader is an accurate method of identifying users, and the buzzer provides feedback on whether a transaction is successful or not.
3. *Effectiveness of the machine learning models:* The ARIMA and Linear Regression models both showed promising results for predicting income. The Linear Regression model had a higher accuracy rate, but the ARIMA model was able to capture the seasonal trends in the data.
4. *User-friendly interface:* The website interface provides an easy way for users to recharge their balance and check the location of the shuttle. This can improve the user experience and increase user satisfaction.
5. *Security of user information:* Since the system stores sensitive user information such as name, registration number, and password, it is crucial to ensure that the data is secure and protected from unauthorized access. In the future, the system can be improved by implementing additional security measures such as encryption and user authentication.

A potential area for improvement is to develop a mobile application for the Smart Shuttle System. The application would provide a user-friendly interface for users to check their account balance, recharge their balance, and track the shuttle buses' real-time location.

Furthermore, the system's security could be enhanced by implementing multi-factor authentication methods such as biometric authentication. This would prevent unauthorized access to the system and protect users' sensitive data.

Finally, the system's hardware could be improved to increase the number of users that can be processed per second. This would help to reduce waiting times and increase the overall efficiency of the system.

Overall, these improvements would enhance the user experience, improve the system's security, and increase the system's efficiency.

## CONCLUSION

The Smart Shuttle System provides a hassle-free, cashless payment experience for students using the shuttle service. The system utilizes IoT technology to provide a fast and efficient payment method and machine learning algorithms to predict income for a particular date. The system has been successfully implemented and tested, demonstrating its potential to revolutionize the traditional payment methods for shuttle services. The system can also be easily adapted to other settings, such as airports, bus stations, and other transportation hubs.

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