

Vehicle Fuel Monitoring and Management using RFID authentication and Telematics Notification

An automated petrol refueling & notifying system

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Abstract— This paper indicates a design in which a system will be capable to trace a vehicle's petrol refill amount, cost & time then notifies the vehicle's owner about the refill as well. The system is divided into two parts: A mobile application and a petrol pump. The users will use the mobile app to register themselves to the system and control their accounts. The users will also have an RFID which will work as a prepaid card. They can recharge the card from any authorized recharge point. The deduction of fuel from the pump for each individual will be automatic after scanning the RFID card and providing a unique password. Cost of fuel will be charged from the RFID card and at the same time, the user will be notified via real-time email technology. All the information of transactions (e.g. refill amount, refill type, refill cost, current balance, previous balance, transaction time etc.) will be sent to a database through Wi-Fi technology. This system has interconnected the pump and the mobile app by a central and secure database so that they can communicate between themselves. The database is accessible from any corner across the world and the users will be able to trace their account through the mobile application at anytime from anywhere. This system can also measure the level of fuel inside the petrol bunk. The goal of this system is to avoid dishonesty of pump laborers & car drivers toward the car owners and provide a secure fuel monitoring method with low labor cost.

Keywords- vehicle's fuel monitoring system; IOT application; arduino mega 2560; rfid; wireless communication; Internet Of Things; Email notifications; ATmega 2560 microcontroller

I. INTRODUCTION

In countries like Bangladesh, day by day the amount of vehicles is increasing spontaneously and causes traffic jam. According to Bangladesh transport authority, there are total 3419884 number of registered motor vehicles in Bangladesh till March 2018 [1]. A lot of fuel stations are engaged in giving services to these vehicles. Current pump/fuel stations need human interactions for providing services to the customers. In most cases, the drivers and pump laborers are not honest. The owner may give the driver \$10 to refill the

car but the driver refills for \$6 and keeps rest \$4. Till now, there is no method developed to monitor these kind of activities. This is one of the reasons we are planning the fuel monitoring system which is based on real-time notification and advanced automation based refueling stations.

The Radio Frequency Identification (RFID) technology can be helpful for the users because there would be no hassle to query for the fuel recording or payment system. Users/Vehicle owners can give the RFID card to his/her driver for refilling vehicle instead of giving cash money. Everything would be online based and machine-based real-time data transformation that means less human interactions. While the user is always using unique passcode there would be less chance of cheating. As the email technology would help to notify users with updated transaction details, he/she will always stay updated and would have every detail that a vehicle owner requires. As the RFID is also working for security concern then there would be less complication of tracing the information. There is a recharge system in our application as well. Whenever a user wants, he/she can recharge. The mobile application will also notify them if the balance is low. The application alerts a user every time when a successful transaction is done by his/her RFID card. By alerting means notifying via both the mobile application and email so that a user knows how much the cost is, what is the amount and when the transaction did happen. The user can also monitor his/her past activities (e.g. transaction statement) through the app.

In this 21st century, technology is expanding faster than anything else and everything is becoming computerized day by day. People are being interested in technology and automation systems. We have found a couple of researches who are working on this topic as well. We want to develop this system for avoiding the dishonest activities and to keep the vehicle owners updated by real-time low cost notifications system. The system should be suitable for many countries like Bangladesh; based on the problems we face on a daily basis.

II. RELATED WORK

Over years, many studies have been conducted to automate the refueling system in various parts of the world. A number of researchers have proposed different types of designs focusing on different areas to improve the refueling procedures. One of the notable work is [2]. This design was proposed by two Indian authors [2] Sahana. S. Rao, and V. Siddeshwara Prasad. In this proposed design, the authors used RFID and GSM technology for automating the refilling system at petrol bunk. The RFID works as a petro card. While a user wants to refill, he/she must swipe his/her petro card to the petro scanner. Then he/she will be asked for password & quantity. If everything goes right and petro card has enough balance to do the purchase, then fuel filling starts automatically. Once the work is done, felling will stop automatically. A user can reload the card by sending a message to the recharge center GSM module at the bunk. Petrol level and smoke detection are also implemented by this proposed model and if the level of fuel inside the bunk is low, it sends an SMS to the bunk owner.

Another notable work [3] is done by Rakesh, Veeresh Pujari and Baswaraj Gadgay. They have also used the RFID and GSM technology to automate the system. Here, the RFID card is also working as a prepaid card. The user recharge the card every time while the balance is low. He/she can recharge his/her card from pump stations. The procedure of dispensing fuel is almost same as the design [2]. The user must swipe the RFID to the petrol bunk's scanner. Then he/she will be asked for password and quantity of fuel. If everything goes error free, fuel will be dispensed automatically. They used the GSM technology for sending a notification to the user informing about the latest transaction. They have also implemented a web server to store the data of users. This server is accessible by any petrol pump around the world. Server is not accessible by any user.

There are also a couple of researches who used RFID and GSM technology to solve different kinds of real-life problems. In [4], the authors proposed a novel method to solve the traffic congestion problem around kindergartens and develop an attendance system. In many countries, it does happen that children picked up for school early in the morning by school bus. Parents don't have any idea of when and whether their children safely arrived in their classroom. To overcome this problem they build this design. According to their design, every student of kindergartens will have active RFID. Attendance will be taken from their RFID card. When any student will give attendance through their RFID, an SMS will be sent to his/her parent's mobile through GSM technology notifying about his arrival. It will also notify the parent as well as the administrators if the student doesn't arrive on time. This system also contains a method to avoid the traffic problem around kindergartens. After class, many parents drive to school to pick up their children. Cars get stuck because of their temporary park in front of school until they find their children. So with an RFID tag carried by the parents, the system is capable to trace the approaching cars

in a specific distance and identify the children who will be picked up next.

RFID cards are also being used as online shopping cards [5]. According to this study, an RFID card is potential to render electrical payments and more secure than a normal credit card. So, in this proposed design, RFID is used as electronic credit card for building a mobile phone based architecture for secure online shopping.

The related works mentioned here offer some ideas to work with Radio Frequency Identification technology, web server and wireless communication technology which is closely related to our study.

III. METHODOLOGY

Dhaka is the most populated and busy city in Bangladesh [6]. The city itself contains the most number of refueling stations. We have visited a few stations and found that, most of the time the drivers came for refueling the cars. Also there are a few number of cars on rent. Car owners are totally unknown about the exact amount of transactions happening in these stations. This is the daily scenario of many refueling stations of Dhaka.

A. Background:

Though some researchers have worked on this topic, we wanted to build a secure & real-time system by which a user can easily trace his/her account's info and get transaction notifications from any corner of the world. We have conducted a few number of surveys in different areas of Dhaka to understand the people's reaction on cheating activities done by their drivers and pump workers as well. Around 100 people participated in our survey and gave their valuable opinion on this topic.

Our survey had questions like, "Do you have any driver for your car?", "How much do you spend per month for fuel?", "Do you believe your driver steal a portion from your refueling cost?", "If yes, how much money they steal you think?" etc.

- 87.6% people have personal drivers for their cars.
- 41.4% people spend around \$178 - \$237 per month for car's fuel.
- 34.5% spend around \$118.50 - \$177.66 per month.
- 20.7% spend \$59.22 - \$118.44 per month.
- And around 5% people spend more than \$296 per month on car's fuel.
- 57.1% people believe, their drivers steal money from refueling cost.
- Among them, 47.8% people think the amount of stealing money is around 6-10%

Now-a-days, we know the cost of fuel has outreached. So 6-10% is a huge amount of money for any developing country like Bangladesh

B. System Architecture:

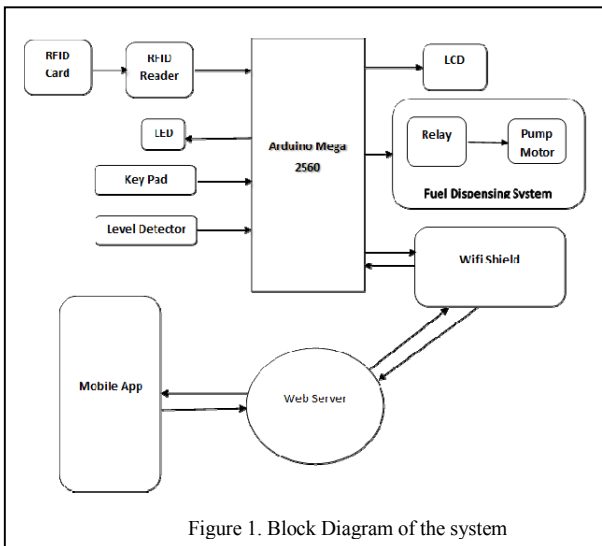


Figure 1. Block Diagram of the system

The diagram above explains how our model's components interact with each other.

C. Process Flow:

The illustration below explains the process of using the proposed design

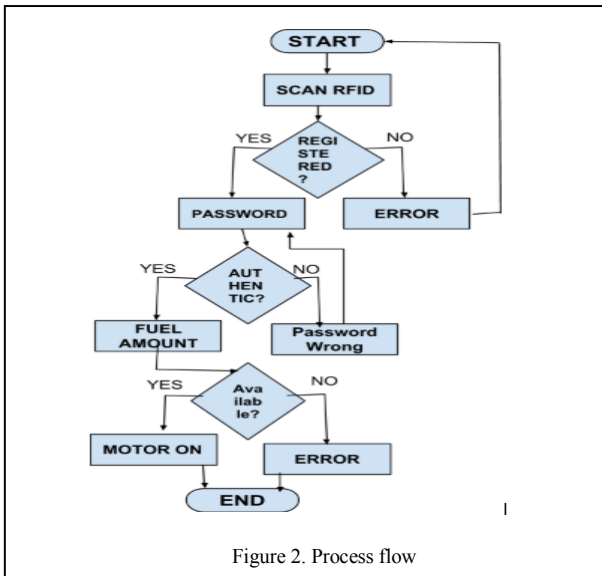


Figure 2. Process flow

To use the system user must follow these steps:

- User have to register himself/herself through the mobile application.
- After registration, he/she will get an authorized RFID card.

- User must scan the RFID card to the petrol pump before refueling.
- If RFID is authorized/valid, then the user will be asked for password.
- If password matched, then quantity of fuel will be asked.
- If the entered amount of fuel & sufficient balance are available then the pump's motor will start dispensing fuel.
- The motor will stop automatically once the required amount of fuel dispensed.
- After that, the user will be notified by a real-time email.

D. System Design:

1) The Android Application:

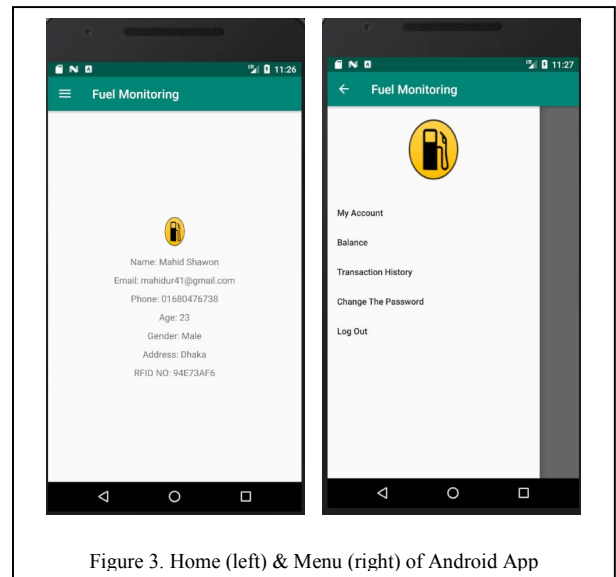


Figure 3. Home (left) & Menu (right) of Android App

We have developed an android application to make the monitoring process easier. The application supports devices starting from android version Jelly Bean 4.1 and onwards. We tried to make the user interface as friendly as possible. Back-end of the App is developed in JAVA and UI is developed in XML. The most important usage of the app is monitoring previous transactions done by the user in last couple of months. The user can check his current balance, profile and edit profile as well. If any problem occurs with RFID, user can also apply for a new RFID from edit profile section.

2) MySQL Database and web server: MySQL is a widely used database system for web based application around the world. It is an open source database developed by Oracle. MySQL is used to build a central database for this design. The database is well structured and maintained

by Fourth Normal Form. There are three separate tables to store the data into the database including a special table called Fuel_Info so that if the rate of fuel changes Administrator can change it from the database anytime. This database can easily be accessed by petrol pumps & user's mobile application from anywhere around the world. Some special PHP files are maintained in our web server so that it can update the MySQL database based on the command Arduino Mega sends. One of the most important tasks of these files is sending the real-time email notification. When a successful disposal happens, the pump will send command to the webserver and then it will send an email detailing the latest transaction to the user.

3) *Hardware:* We have built a well-structured demonstration of this system with a couple of low cost hardwires. As explained in the block diagram of the design (figure:1) , the design needs:

- Arduino Mega 2540
- MFRC522 RFID Reader
- 13.56 MHz RFID Card,
- 16*2 LCD Display
- SRD-5VDC-SL-C Relay module
- Pump Motor
- Red Led
- Matrix Keypad (4*4)
- HC-SR04 Ultrasonic Sensor
- Ethernet Shield W5100

The Arduino Mega is an open source microcontroller board based on ATmega2540 consisting of 54 digital I/O pins, 16 analog analog inputs and 4 UART communication ports [7]. It is the brain of this automated petrol pump. Every single module is connected with this microcontroller board. When user scans his RFID card, it collects the data from RFID reader and sends it to the database server. The database also sends the query results back to the Arduino. If a perfect match found, then it will command the LCD display to ask user for password. Again, the password will be collected by this Arduino board & it will run a query to the database for valid password. After this, user will give the amount of fuel he wants to buy. Arduino will calculate the cost and check if the balance is available or not and also send a command to Ultrasonic Sensor module to check if the pump has enough fuel or not. After receiving all valid results, it will turn on the pump motor. Then, after a successful transaction it will send command to webserver for sending email to user notifying his transaction. So, the board is basically controlling every single movement of other modules connected with it.

MFRC522 is a low cost RFID reader module which is easy to use and available almost everywhere. In our design, the module is connected with the Arduino Mega board. When an user scans his/her RFID card, it reads the unique RFID number from the card and sends it to the Arduino board. The frequency of MFRC522 is 13.56 MHz [8], so the frequency of user's RFID card must be 13.56 MHz as well.

Another module is 4*4 matrix keypad. It is used mainly as an input module in many projects. We used this module for taking input from users. After scanning the RFID, the user will be asked for his password. User have to give the password through the keypad. The keypad will send the data to Arduino board.

There is a 16*2 LCD used in the demo so that we can show the outputs and error messages. The LCD module takes commands from Arduino and shows data/message accordingly to the users.

The system detects the level of petrol inside the pump by a HC-SR04 Ultrasonic Sensor. The sensor is attached at the top of the petrol bunk facing down to the petrol. It senses the distance of petrol from itself and send the data to Arduino. Then the Arduino can calculate the available amount of petrol inside the bunk.

Arduino can supply maximum 5V DC to other modules connected with it [7]. But the pump motor used in our demonstration operates at 12V DC. The real pump motors at petrol stations need AC voltage supply and the range may differ from 200-220V. So the Arduino cannot directly control the motors. We used a SRD-5VDC-SL-C relay module to control this motor. The relay operates at 5V [11]. That means Arduino can turn on/off the relay by supplying 5V DC voltage. Once the relay is turned on, it allows AC/DC current to flow through itself. By this process, the main circuit remains risk free from AC current.

At many stages, Arduino Board needs to communicate with web-server to ask for data, update database, send notifications etc. Arduino does not have the capability to communicate with the web-server. So, an Ethernet Shield W5100 is connected with the Arduino. It receives commands from Arduino and then sends & collects data from web-server as well.

IV. DEPLOYMENT AND RESULTS

We have conducted a few number of test cases on the prototype we built. During the test phases, some points were noticed.

a) *Speed of data transfer may vary depending on internet speed.*

- b) The system took an average time of 5 seconds to send the email notification to the user.
- c) The app took less than 1 second to update it's user interface.
- d) The petrol pump was 95% accurate during petrol's quantity/level detection.

Figure 4 shows the front side and back side of our proto-type. We have also made a admin interface for the administrators or controllers of the system so that they can

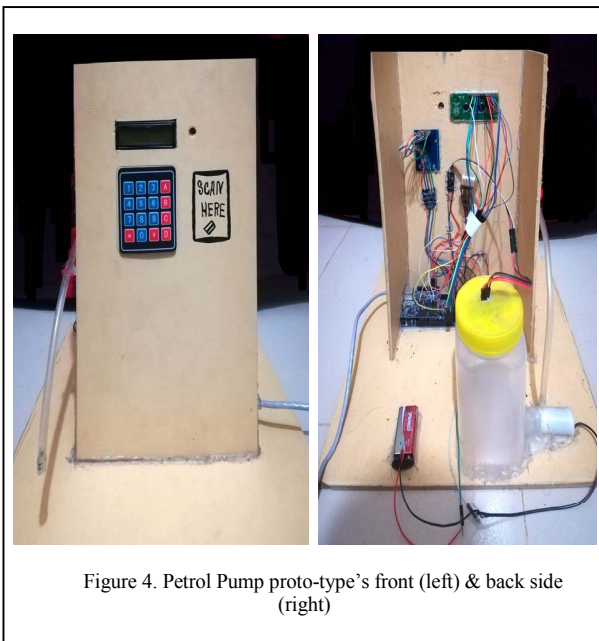


Figure 4. Petrol Pump proto-type's front (left) & back side (right)

change the RFID card of any user on request. Online recharge technology is also a popular in recent age. It gives the users a hassle free recharge experience. So we kept a recharge option at admin interface as well. Figure 5 shows our demonstration of admin interface.

We tried to make a visualisation of the Email notification also. Figure 6 below demonstration how the email notification looks like.

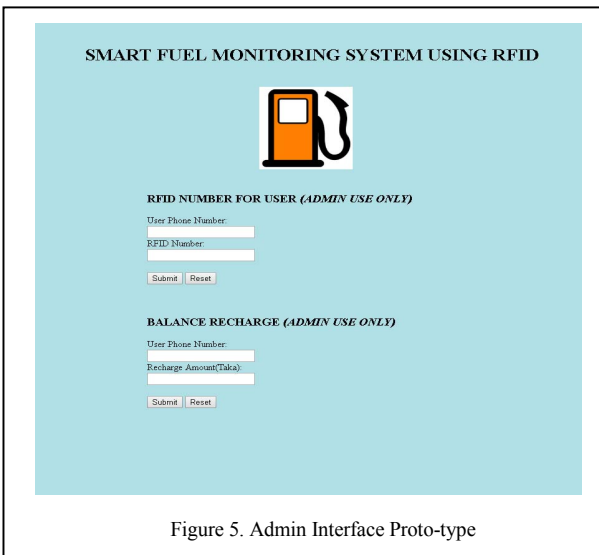


Figure 5. Admin Interface Proto-type

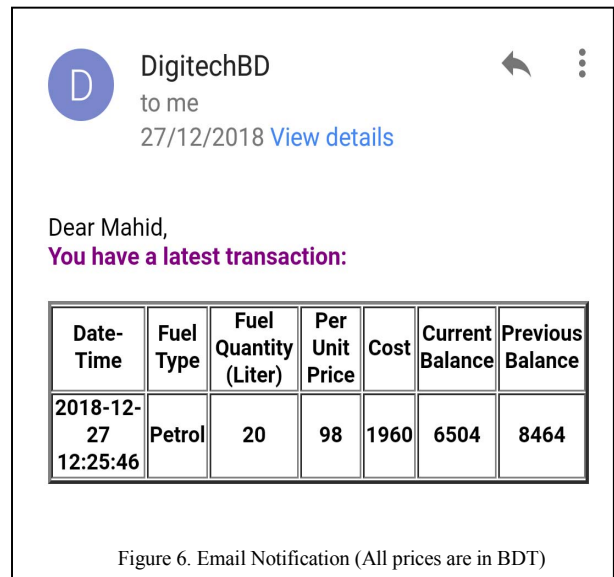


Figure 6. Email Notification (All prices are in BDT)

V. DISCUSSION

Overall cost of our proposed design was about \$25/per unit. This one unit consists of 1 petrol pump machine. Which can provide automatic services for the numerical number of vehicles.

We mainly faced a problem to deploy a real pump machine, because of huge cost. Instead of a real pump machine we deployed a prototype of pump machine with the same functionality.

VI. CONCLUSION

Though RFID technology is being used in many sectors of security field, our system includes mobile application and automated fuel disposal pump with RFID technology which makes the system more efficient, secure and user friendly.

There are some regulated gas stations in many developed countries which generates computer printed receipts. This may solve the issue of cheating activities. But our proposed design gives real-time notification as we as it reduces human interactions in refueling process which means low labor cost in refueling business for the station owners. These reason can motivate the station owners to use the proposed model. It also keeps record of data. Data can be useful in many occasions regarding business and economical analysis. The system can be implemented in every country for helping people to trace the quantity of fuel they are buying and the amount of transaction they are doing, this data may help to know about the economy of a country. This system will ensure the accuracy of fuel disposal and also will be able to stop system loss, which causes a great loss for both user and owners of the pump.

So, therefore this system can make a great change in socio economic sector of a country.

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