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Design and Implementation of RFID-based Fuel Dispensing System

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Abstract: This paper presents a fuel dispensing system based on RFID technology. The system can improve the fueling process in order to make it much easier, secure and reliable. It prevents unauthorized fueling by assigning a specified amount of fuel for registered vehicles, depending on their types, within a specific period of time so that each vehicle will get a sufficient amount of fuel. It also provides efficient statistics about the various quantities of fuel at the stations. The system was implemented at the *Oil Products Distribution Company, The Distribution of Baghdad.* It uses ELA816B RFID reader with its passive tags. It has a software application, built using VB.Net, for registration of customers, updating their accounts and charging them for the designated amount of fuel. The hardware part of this system consists of a microcontroller, card relay, LCD and other basic electronic components, and it is attached to conventional fuel dispensers in order to make them work under the RFID technology. The system uses a centralized database to allow fuel stations to share the same data about vehicles and related balance. Additional features of this system include a website and a phone application, which allow customers to login to their accounts.

Keywords: Radio Frequency Identification (RFID), Fuel Dispensing System, Automative Fuel Control

1. INTRODUCTION

The uncontrolled increase in the number of vehicles in Iraq in recent years has led to the congestions and long traffic jams in almost all Iraqi cities. The dispensing of fuel to this huge number of vehicles at the conventional fuel stations has caused many accumulated complication factors in Iraq. One such factor is that the vehicle driver has to pay for fuel with cash money and may have to pay more than the amount of dispensed fuel due to the lack of small money change available with station operator. Also, there is the nonexistence of rationing to the amount of fuel being dispensed to each vehicle. Another important factor is that all reports about the supplied, dispensed, and remained quantities of fuel at the fuel stations are paper-based reports and mostly, there are no reliable statistics about such amounts.

The petroleum products are one of the valuable and rare creations of the nature. The proper use and distribution is an important task to survive these products [1]. A fuel station is a facility which sells fuel and lubricants via fuel dispensers or otherwise called bowsers which themselves are used to pump gasoline, diesel, kerosene, etc. into vehicles and to calculate the financial cost of the product thus dispensed [2]. Enterprises engaged in urban and suburban public transport as well as other transport enterprises, big fuel consumers, need control of fuel delivery to prevent or at least minimize the misuse of fuel [3].

In present days, most fuel stations are manually operated which require more manpower and are time consuming. In order to place fuel stations in a distant area, it is so costly to provide an excellent facility to the consumers [4]. Public transportation companies aim to include quality and modern technologies in their services hoping to realize the optimization of the employed material resources [5]. Using technology in the delivery of service has changed the way services are delivered and designed. This includes self-service technologies such as self-service fuel dispensers or automated teller machines. This has been made possible through the use of computers and the Internet [6]. Older identification systems were not reliable enough. For example, in system with paper vouchers, there is a real threat of fake coupons, which are difficult to distinguish from the original ones. Furthermore, there is no clear insight into daily, weekly or monthly fuel dispensing neither how many vouchers are remaining in circulations [7].

The emergence of radio frequency technology has changed the traditional methods of data collection. Compared to the traditional bar code, magnetic card and

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IC cards, RFID tags have the features of non-contact, reading speed, no wear, long life, user-friendly and the security function [8]. RFID is replacing barcode technology and enjoying the major advantage of being independent of line of sight problems and scanning the objects from a distance. It offers the promise of reduced labour levels, enhanced visibility, and improved inventory management [9].

The uses of RFID for vehicle identification, toll collection, traffic management, and parking lot management have already been experimented with extensively [10]. This paper proposes the implementation of RFID technology in controlling fuel dispensing for an Iraqi city.

2. RADIO FREQUENCY IDENTIFICATION (RFID)

Radio-frequency identification (RFID) is a method of transferring of data wirelessly using electromagnetic fields [11]. An RFID system is usually composed of three main components: (i) tags, (ii) a reader and its antennas and (iii) a middleware application that is integrated into a host system [12].

There are three main varieties of tags: Active, Semi-active and Passive [13]. Tags without internal power supply, are called passive tags, tags without internal power supply, but only use the internal supply for their internal memory circuitry are called semi-active, while tags that use their internal power unit to power both the internal circuitry and the antenna unit for communication are called active tags [14]. Fig. 1 shows a typical RFID system.

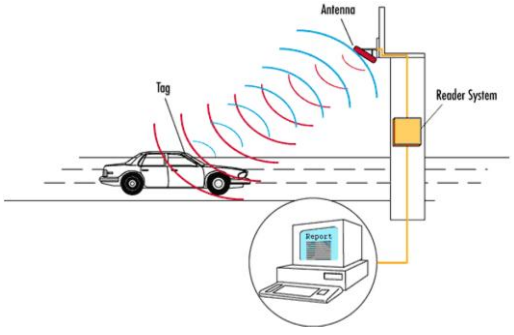


Figure 1. A typical RFID system [13]

3. FUEL DISPENSERS

A typical fuel dispenser consists of two main parts; mechanical and electronic. The mechanical part has a motor, a pump, and a flow meter. While the electronic part is an embedded system (CPU) that controls the dispenser and it has a micro switch, a pulser (rotary encoder), a card relay, a keypad, a display and solenoid valves [15]. Fig. 2, Fig. 3, and Fig. 4 display these parts.

Figure 2. Fuel dispenser embedded system

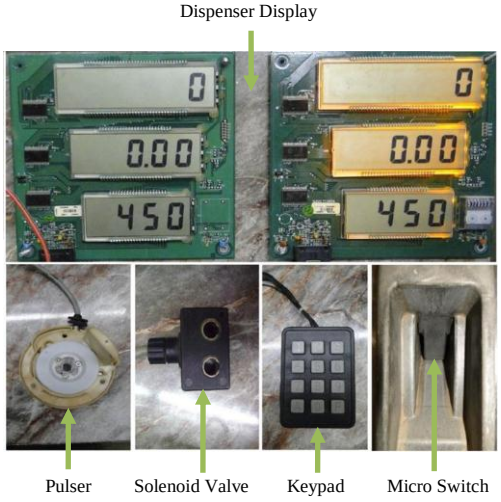


Figure 3. Main components of a fuel dispenser

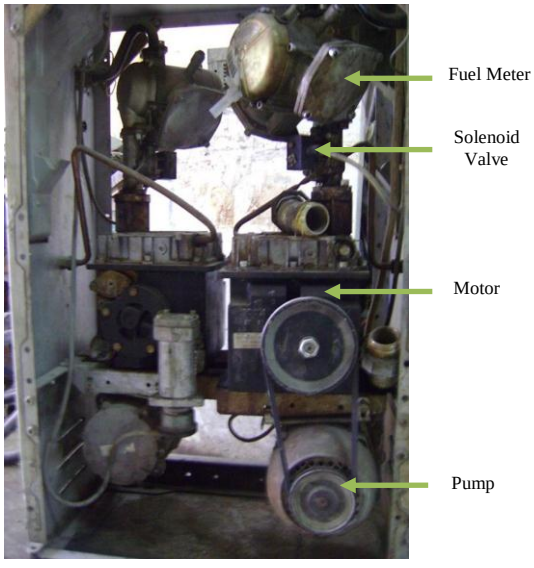


Figure 4. Mechanical parts of a fuel dispenser

The ordinary operation of fuel dispensers is mostly the same for all fuel dispensers. When the nozzle is pulled out of the dispenser pump, the micro switch sends signal to the dispenser control unit, which sends the required signals to the internal components in order to activate the dispenser [15].

The system to be presented in this paper will adopt the RFID technology in order to automate such operation of the dispenser and enhance the fuel dispensing process.

4. SYSTEM OVERVIEW

Customers that use this system for the first time have to register and create an account. This account includes specific information about the driver/owner, the vehicle, and the allocated balance. An administrator is responsible for creating the account for customers. The account is stored in the system database and it is associated with a unique ID that is the same as the ID of the tag assigned to the specified vehicle; so when this ID is detected by the reader, the system will know that this tag is related to a specified customer. The RFID readers are to be installed at the fuel stations, one for each fuel dispenser.

Each vehicle type is associated with a predefined amount of fuel available to be dispensed within a predefined period of time, typically one week. At the end of fueling, the amount dispensed is deducted from the related balance; so the new balance will replace the old one and will be available for next filling. The MySQL database is the database server chosen for this system. It is a central database which can be accessed by the fueling application software on a host located at each fuel station. This requires a fuel station to have a fast internet connection for processing data; so that balance for customers can be updated at the fuel station. The host computer can run multiple fueling applications at a fuel station, which are used to manage fueling operation at each dispenser.

When the predefined amount of fuel ends, the vehicle cannot get the fuel until another amount of fuel is set for it in the following week. The new amount is subtracted from the total amount of liters that the customer paid for an earlier time. Fig. 5 shows the main architecture for this proposed system.

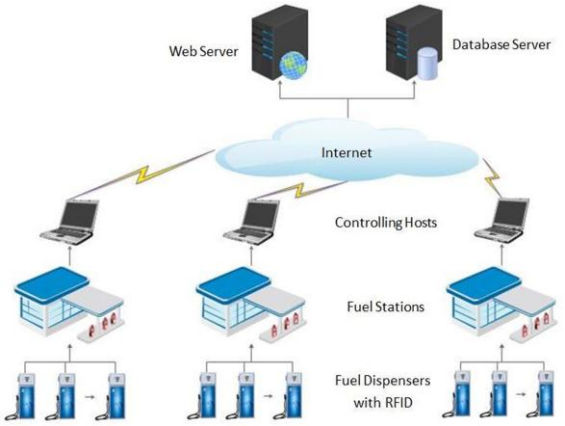


Figure 5. System architecture

5. SYSTEM STAGES

The system has two main stages which control and manage customer accounts and the fueling operation as well as managing administrator accounts and fuel station information.

A. Registration & management

This stage represents the application software of the system which contains the forms used for registration and managements of accounts and their data. This application is programmed using Microsoft Visual Basic.NET program. Fig. 6 shows a block diagram for this stage. Each block represents a form that has a specific action and procedure. These forms are responsible for creating new accounts, charging for accounts, and updating accounts information and status. Also, all the data related to the fuel stations can be managed.

The detailed information about every fueling process can be displayed at this stage. Such information is very beneficial to this system; since it collects data that contains important statistics about various quantities of fuel, vehicles that get the fuel, and the date and time of fueling. Based on these statistics, many reports can be generated, which can be used to enhance the system as well as the whole process of the fuel dispensing in a very effective way. The system is able to record all vehicles, detected by the readers of the fuel stations, with the related information. This can help in tracking procedures that the system might need for certain reasons.

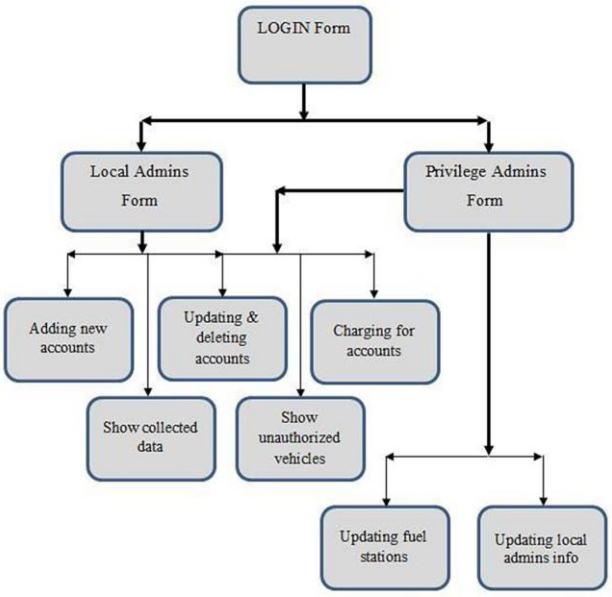


Figure 6. Block diagram of registration and management stage

B. Fueling operation

This stage of the system allows customers to get the fuel. It has an application form for this purpose. The RFID readers at the fuel stations are used to identify vehicles approaching the fuel dispenser.

As a tag ID is detected, the system will retrieve related information from the database server, and recognize the validity of this ID, and actions will be taken accordingly. Unauthorized vehicles cannot get the fuel. Else, if the vehicle is licensed to get the fuel, the system will activate the fuel dispenser to be ready to supply the fuel for that vehicle.

At the end of the fueling process, the system turns off the dispenser. If there is a remaining amount of liters, this amount will be set for this account as the new balance to be fueled next time. Otherwise, there will be no liters to be fueled until that account is updated.

Unauthorized vehicle is set by the system due to reasons imposed by the system or because of legal issues. When such vehicle reaches the dispensing unit, the system recognizes such vehicle and activates a warning message. In this way the system can easily detect the location of this unauthorized vehicle.

6. IMPLEMENTATION AND RESULTS

Implementation of RFID technology has changed the procedure of the operation of conventional fuel dispensers. The practical implementation of this system is done at the Ministry of Oil, Oil Products Distribution Company, The Distribution of Baghdad. The system was installed on one of the fuel dispensers. Fig. 7 shows the hardware module with the RFID reader that is connected to the dispenser.

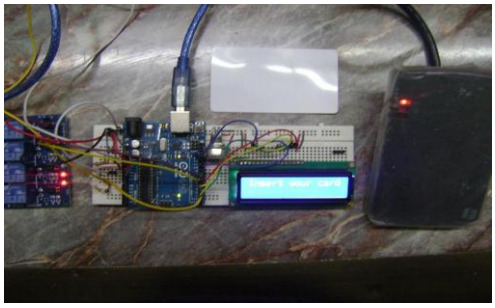


Figure 7. RFID reader with the hardware module

The hardware module consists of an Arduino microcontroller, a card relay, an LCD, and other basic electronic components.

Internal components of the fuel dispenser, including the micro switch, the pulse, the solenoid valves, and the keypad, were used for the implementation and were connected to the hardware module. This module will then control the fuel dispenser and can be considered as the new embedded system of the dispenser, i.e. all signals that are used to activate the dispenser unit and its components will be manipulated by this new embedded system.

When the fuel dispenser is switched on, the fuel will flow through the fuel meter, so the pulser attached to that meter will send signals to the hardware module, which is used to count the dispensed liters. This is an efficient way in the implementation; since the system will rely on the calculated liters for accomplishing various procedures.

Fig. 8, Fig. 9, and Fig. 10 show the final form of the hardware module and the connections with the fuel dispenser.

Figure 8. RFID reader and the hardware module enclosure

Figure 9. The hardware module connected to dispenser

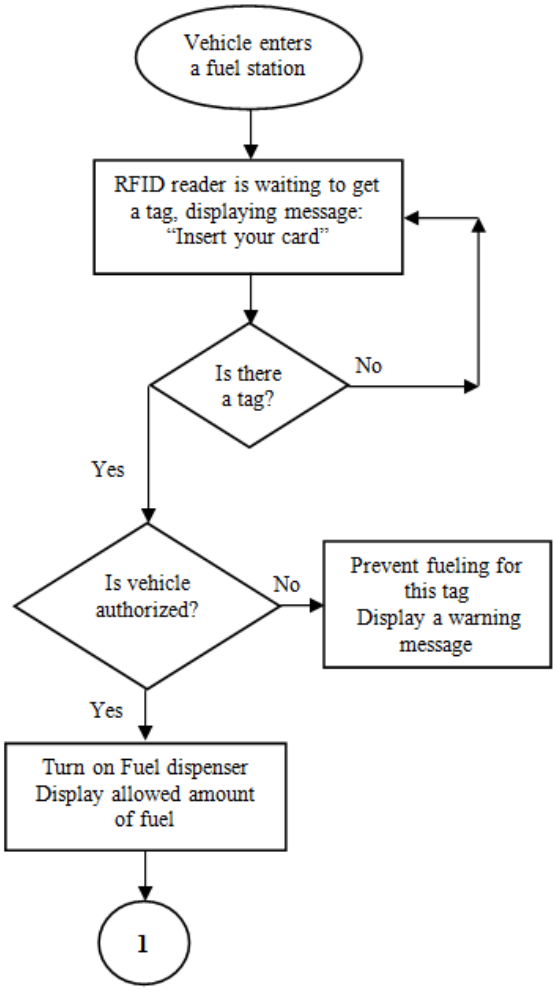
Figure 10. Hardware module attached to dispenser at a station

When a vehicle enters the fuel dispenser lane, the RFID reader is ready to read the tag assigned to that vehicle. If that vehicle is authorized to get the fuel, the system will give the permission to the micro switch to send the required signal that is used to turn on the fuel dispenser. A message, with the available amount of fuel will then be displayed on the LCD, and the customer can fuel the desired amount. If there is no tag or the vehicle is unauthorized to get the fuel, the dispenser will not be activated.

If the fueling reaches to the end of the allowed amount, the solenoid valves will be used to prevent exceeding that amount. This ensures the accuracy of fuel delivery. If any amount is typed using the keypad, the customer can get that amount as long as it is within the available balance. Again, the solenoid valves guarantee the precision of the delivery of that typed amount.

When a valid tag is detected, but fueling does not start, a timer of ten seconds will be activated. Then, the dispenser will turn off. Also, if the fueling operation stops for ten seconds, the dispenser will turn off. This can help to keep the customer balance safe and prevent any fraud or illegal use of that balance by another person.

At the end of the fueling operation, the fuel dispenser will be deactivated and another message appears on the LCD with the remaining balance. Then, the reader will be ready to get another tag of another vehicle. Fig. 11 shows a flow chart that describes the entire fueling operation and the appropriate actions taken by the system during the presence of the vehicle in the fuel station.



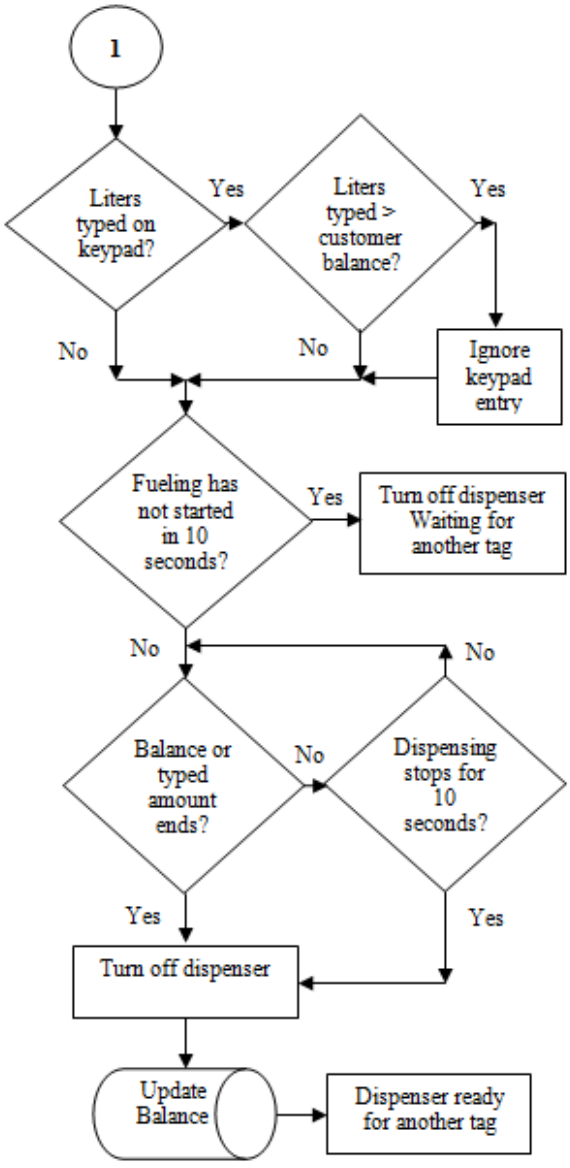


Figure 11. The fueling operation flow chart

7. WEBSITE AND PHONE APPLICATION

The website describes the main feature of the system, including objectives and operation; so it has several web pages for that purpose. It was built using PHP, HTML, and CSS languages. The Login page is the most important page of the website; since it allows customers to check their balance and the permitted amount of fuel they can get for the current week.

The phone application is based on Android. Its major purpose is for the Login. It gives customers a quick access to their accounts, like the login page of the website, using their smart phones.

8. CONCLUSIONS

This paper introduced a preliminary system to implement RFID technology in the fuel dispensing in an Iraqi city. The following points are concluded for such system:

- ✓ The system allows customers to pay just for the amount of fuel they get and prevents illegal sale of fuel by assigning a predefined amount of fuel within a specified period of time.
- ✓ Existing dispensers at fuel stations can adopt this system without the need to install new ones. This is considered an efficient way to implement the system and reduce costs, since there are many different types of fuel dispensers in one city.
- ✓ Throughout this system, many useful records can be drawn such as the amount of liters being supplied in a particular fuel station, the main customers that dispense the fuel, depending on the type of their vehicles, and many other needed reports.
- ✓ By referring to the collected statistical reports, the performance of the system can be improved by adopting the required updates.

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