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Research Article

RFID based on the design of a new fuel recognation system

Fatih Maraşlı [1]*, Musa Çıbuk [2]

[1] *Bitlis Eren University, Ahlat Vocational School, Department of Computer Technologies, Bitlis - Turkey*
[2] *Bitlis Eren University, Faculty of Engineering and Architecture, Department of Electric-Electronic, Bitlis - Turkey*
* *Corresponding author: fmarasli@gmail.com*

Abstract

A new fuel recognition system based on Radio Frequency Identification (RFID) technology aims to provide a solution for the problems that occur during refueling process of vehicles such as wrong type of fuel filling and misusage of pumps, especially in fuel stations. The RFID tags are placed both in vehicles and stations consistently due to the proposed system. A software interface is designed for visual tracking of the system using the C# programming language. The developed interface works with the integrated RFID application development kit. Reading and writing operations on tags are performed via this kit. The results are shown at the interface display. The process of data storage is done by means of a created database, both on server systems and in the memory of the tag. Also in the mini-survey results carried out under this thesis, it is inferred that this system would be a solution for the financial and depreciative loss of fuel stations.
As a result, with the system developed in this study, an effective and practical solution is provided against refueling errors. Thus, it would be possible to overcome this kind of errors which cause traffic and vehicle problems.

Keywords: Wireless Technologies, RFID, Application Areas, Fuel Control System.

1. Introduction

Wireless technologies have great importance in our daily life. Most basic technologies such as WiFi[1], Bluetooth[2], the NFC[3], IrDA[4], and ZigBee[5] in wireless communications are used in many fields. Today, thanks to increasing smart phone usage, these technologies have already been delivered to many users. File transmission / reception, video calls, sharing devices and many other applications are possible through the use of wireless systems.

This development of wireless systems found a great place in areas such as war technology [6], applications requiring data privacy [7], and manufacturing activities. In the middle of the 20th century RFID (Radio Frequency Identification) was developed to be used in war technology which has taken a leading role in wireless systems. The rapid development of this technology was developed to describe the physical object as a result this activity has contributed to the production activities significantly too. Today, developed and grown RFID systems are preferred in terms of important criteria such as costs, production time in manufacturing operations and supply chain. Today, RFID systems may be used as an alternative to bar code systems.

RFID technology can be developed and used in many areas; flexible, reliable and cheap. So, application areas of this technology has been tried to be a solution to problems in fuel stations examined in details in this study.

2. Material and Method

In this study, by using RFID technology, it was tried to bring a solution to an engrained problem in the fuel station. As materials, Alien ALR9900+ development kit and an interface with the C # programming language in connection to the computer has been developed.

2.1. RFID Technology

RFID is called as identification of Radio Frequency. So, components of the RFID communicate with radio frequency. RFID is consisted of three basic components; the reader, the tag and the antenna. Readers are the components that receive the data of the object via the tags and transpose the data to numeric codes by using radio waves. Tags are the components that store the information. The communication between the tag and reader is provided by antennas and that is called as "coupling". Extra antennas are used to extend the reading distance. The basic operating principle of RFID is shown in Figure 1.

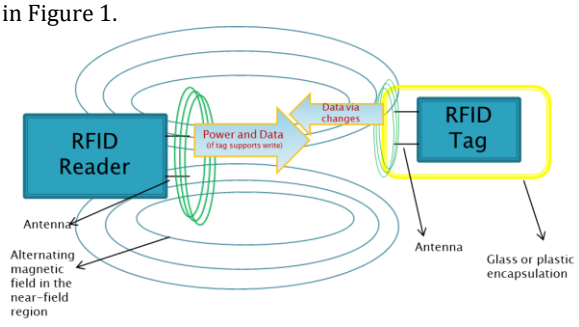

Figure 1. Power/communication mechanism of tags at lower frequencies than 100 MHz in the close space [8]

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2.1.1 The Components of RFID System

To summarize RFID; it has a microchip in its content that contains information about the object, can do tracking and analyses an attached antenna to this microchip and an automatic identification and tracking system that enables the exchange of data via radio frequencies using a tag that can be integrated into objects. There are three basic components involved in the exchange of this information. These are readers, tags and antennas. The electromagnetic waves emitted by the reader reach the antenna of the tag. These waves activate the microchip in the tag and the waves are sent back by the microchip reader by modulating via antenna. The data received by the reader is displayed by converting to a digital form. There are controllers that take part in storing system data in computer and are in connection with middleware. So units which function the entire based on this system can be listed in two groups, as hardware; RFID Tag, RFID Antenna and RFID Reader, as software; the Controller, the EPC code and Middleware software.

2.2. Materials Used In Design

RFID development kit used in the design of the fuel recognition system is Alien ALR 9900+. Set consists of a reader, two circular polarized antennas, a software development kit (SDK), a power cable, a RS-232 cable, a cross-linked Ethernet cable and several sample tags.

The reader supports EPC Gen 2 and ISO 18000-6C tag standards. The reader; has a Xscale processor, hosts Linux operating system, has 64 MB RAM and 64 MB Flash. It works in the 902-928 MHz frequency band, 50 transmission channels and 500 kHz channel spacing. Reader provides a connection with LAN TCP / IP (RJ45) and RS-232 (DB-9 F) inputs. The reader has 4 ports that can be attached to circular and linear polarized antenna. PR-ASK (Phase Reversal - Amplitude Shift Keying) is used as a modulation method. There are 4 inputs and 8 outputs and a serial port. The applications may be developed in the Java, .NET and Ruby APIs languages with this development kit [9]. Reader is shown in Figure 2.

Figure 2. Alien ALR 9900+ development kit

Antenna used in the design of fuel recognition system is TPS-UHF9ABH 9dB linear model antenna as shown in Figure 3. It is capable of reading up to 12 meters.

Figure 3. TPS-UHF9ABH model antenna

The sample tag used in the design of the fuel recognition system is Alien ALN-9662 short model tag as shown in Figure 4. The tag supports EPC Gen 2 and ISO / IEC 18000-6C standards. The frequency range of tag is 840- 960 MHz. Total memory of tag is 800 bits. It is dedicated 32 bits of this memory for TID (Tag Identification), 62-bit original TID, 96-bit EPC, 512 bits of user memory, 32-bit access password and to 32-bit password to destroy tag [10].

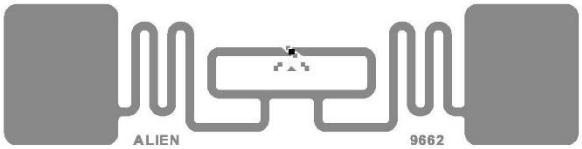

Figure 4. Alien ALN 9662 short model tag

2.3. Solution Approach of The System

The scenario of fuel recognition system that developed in this paper is shown in Figure 5.

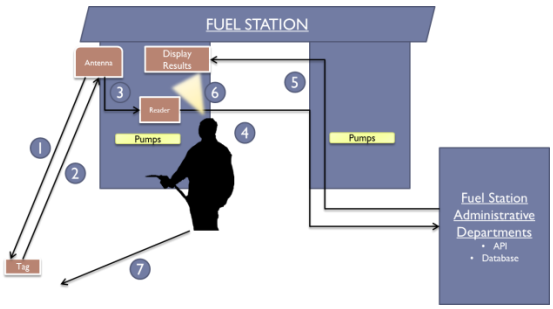

Figure 5. Scenario of the system

Firstly, the electromagnetic waves emitted by the antenna activate the tag. It receives the information as bitwise (1). Then the tag returns the information as the bitwise with the stimulation received from antenna (2). The reader reads the information as bitwise through antenna which is connected. Data conversion is carried out (3). Information from the tag to the reader is transferred to the database by using the application software through the middleware (4). After that, the information in the database is displayed as a list and transferred to the monitor thanks to application software (5). Finally, the station employees see the information, coming from the tag (fuel type, such as plate), on the monitor (6). Thus, station employees can fill fuel the vehicle in faster and more reliably way with the information on the monitor (7). The architecture of the developed system is shown in Figure 6.

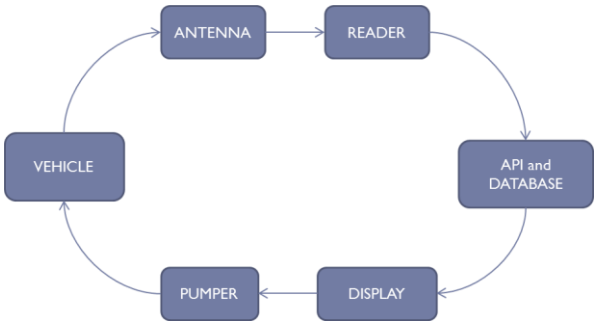

Figure 6. The Architecture of the system

At the loop of forming architecture, the tag in the vehicle is recognized remotely by the system when the vehicle enters the station. The tag information detected by the antenna reaches the interface, which we have designed, by transferring information to the reader. The information reaches the station employees by displaying information on the monitors.

2.4. A Survey

A mini survey about the subject is carried out in this paper, and especially the number of refueling errors in a year is asked. According to the responds the graphics are shown in Figure 7. The numbers of refueling errors among 50 stations; 14 stations said between 1-3, 14 stations said between 4-6, 9 stations said between 7-9 and 13 stations said more than 9.

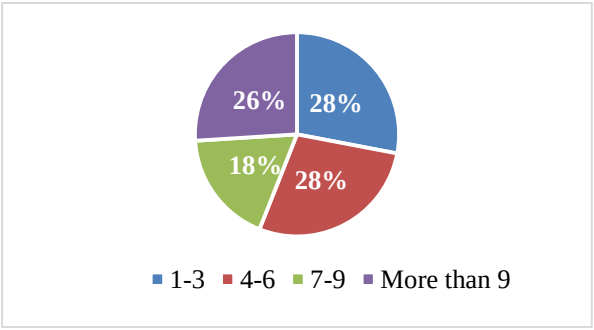

Figure 7. Number of refueling errors made during a year.

Two answers are received when the participants are asked how they bring solutions against these type of errors: If vehicle hasn't moved, the tank is emptied and recharged by a master. If vehicle has moved, the vehicle is directed to the service.

Costs incurred with the renewal of the fuel in the tank when the vehicle hasn't moved are shown in Figure 8. It is seen here that 19 stations out of 50 stations gave an overall response of TL 500-699. Even if the least possibility is considered, when the lowest error numbers and lowest cost according to the weighted answers are multiplied there is a loss between TL 500 and 1500 per year of a station.

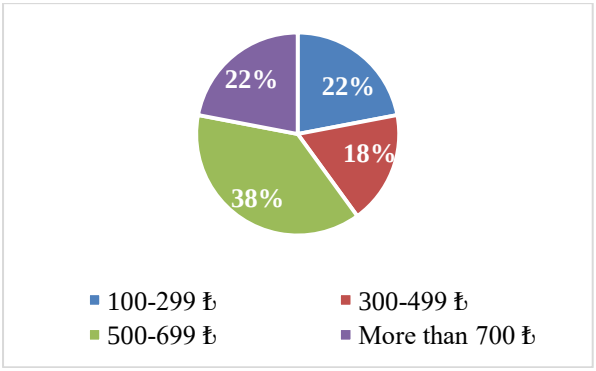

Figure 8. The cost damage to the station if the car has not moved after refueling error.

And vice versa, if the vehicle has moved, cost incurred after directing to service is shown in Figure 9. The result of this survey shows that if the error is large, the lowest cost according to the weighted answer is multiplied with the minimum numbers of error; there is a loss approximately between TL 3000-15000.

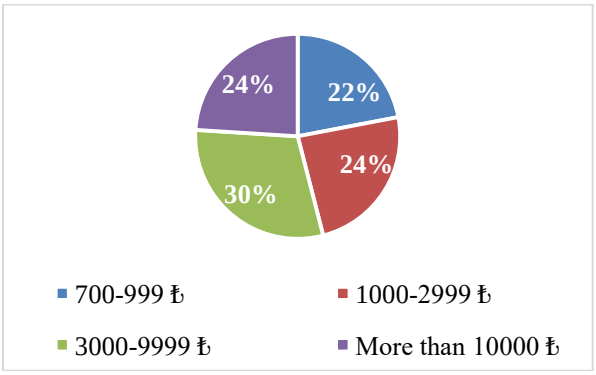

Figure 9. The cost damage to the station if the car has moved after refueling error.

When the damages caused by the faults of stations are asked, the same answers were given in general. These are;

- Value loss of station
- Financial losses
- The increase in the payment limit of the station to his insurance company.

When it is asked what information you need most if a system is built to remove these errors and this system gives information about the car (plate, color, brand, model, fuel type etc.) the weighted answers are ; plate, brand and fuel type. Finally it is asked to the stations "Will you consider buying a system that gives this information?" they substantially (96%) have responded positive reaction. Graphics related the given responses are shown in Figure 10.

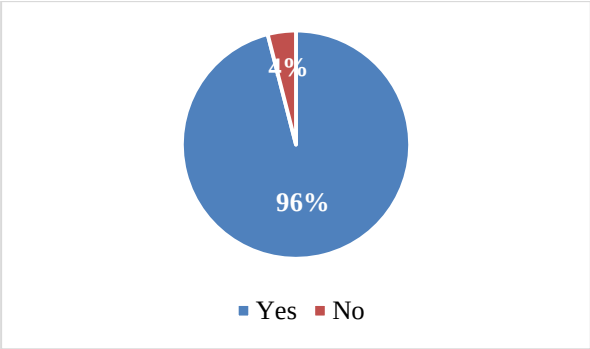

Figure 10. Demand on ratio concerning to proposed system for eliminating errors.

2.5. RFID-Based New Fuel Recognition System

One of the main problems encountered at the fuel stations; incorrect fueling of car. Besides that, there is also a situation where the pump worker loses time to get the vehicle information. In light of this information, a new RFID-based fuel recognition system has been developed in this study. In order to bring a basic clarification to the existence of the problem, a mini-survey was conducted (as mentioned above). The survey results show that;

Incorrect fuel filling of the vehicles is usually carried out by new personnel at the station or by staff who are close to shifts. Station that makes wrong filling 3 times a year on average, if is thought to be noticed before the vehicle hasn't move, the lowest cost is between 500-1500 TL. If the vehicle has move, cost is average between 3000-15000 TL. A prevention system to be designed, 96% of 50 stations have found beneficial and have expressed that it must be found in the station.

In addition, another problem that is met at the station is to bill for another vehicle's plate. In order to prevent this problem, except for records kept by our system, the system may become eligible to detect it if the invoice is made out. In this way, tax evasion is prevented. The application interface (API) designed with C# programming language is shown in Figure 11.

Main Form

Figure 11. The main form of program

The connection process with reader in all forms is performed by okuyucuBaglanti() function that is created in a class named rFuelConnect. This class and function;

```
public partial class rFuelConnect {
       public static clsReader mReader = new
clsReader();
       public static CAlienServer mServer = new
CAlienServer();
       private delegate void showMsg();
       public static void okuyucuBaglanti(){

       }
}
```

The reader's automatic reading mode is turned off in the process of closing the all forms window. The information on cache memory of reader is reset.

```
rFuelConnect.mReader.AutoMode = "OFF";
rFuelConnect.mReader.Dispose();
```

There are 3 Buttons, 1 GroupBox, 1 Label and 2 toolStripStatusLabel on the interface. The basic objects on the interface are collected in GroupBox. If a problem occurs in reader, reader is restarted with "Readers Restart" label. The function used for this operation is;

```
private void readerRestart_Click(object sender,
EventArgs e) {
            rFuelConnect.okuyucuBaglanti();
            rFuelConnect.mReader.Reboot();
}
```

Command line used to display the date and time information under the main form is;

```
toolStripStatusLabel1.Text =
DateTime.Now.ToLongDateString();
toolStripStatusLabel2.Text =
DateTime.Now.ToLongTimeString() + "     ";
```

The information to be recorded in the new label is entered to the form which is opened by clicking the define new label button on the interface. The function that displays the identification form of new tag;

```
private void newTagButton_Click(object sender,
EventArgs e) {
            writeRFuel wRfuel = new writeRFuel();
            wRfuel.ShowDialog();
 }
```

The "tag read" button on the interface is used to read tags in vehicles. Tag reading form that views after is clicked the read button once, is updated as new tag information come. The tag on the vehicle coming to the station is read from the remote and necessary information is displayed on the screen. According to the tag information on the screen, the car is filled by the pump officer.

The "edit tag" button on the interface is used for editing tag. In the window that opens after a single click on the button; firstly the tag is read, then updating operation is finished by doing necessary corrections.

2.5.1. New Tag Identification Form

New tag identification form is shown in Figure 12.

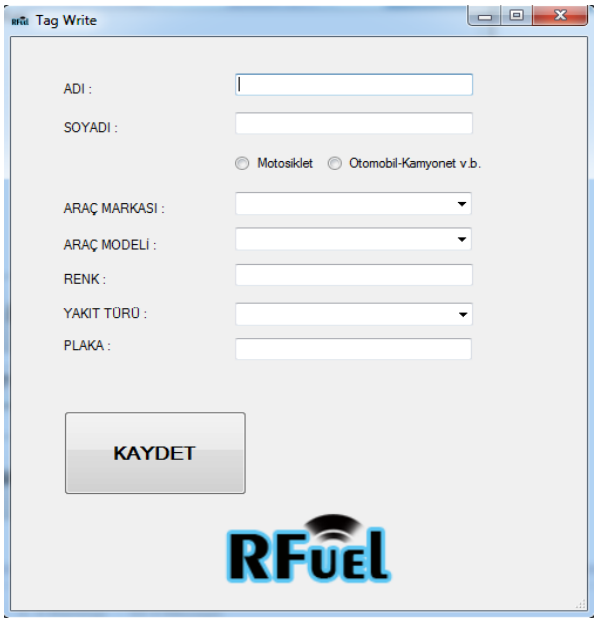

Figure 12. New tag identification form

The information on the new label identification screen consists of name, surname, vehicle type, brand, model, color, fuel type and plate. This information is also stored in a database. The tags are mounted on vehicles after the information is recorded to them. The function used to record information on the tag and the database is;

```
private void tagSaveButton_Click(object sender,
EventArgs e) {}
```

The text of fuel and plate information entered in the tags identifying form are converted to hexadecimal format that can be stored on the tag. The functions that doing this process;

```
public string ikiliBolme(String ascii) {}

public string ConvertStringToHex(String ascii) {}
```

Establishing a connection with the reader during the loading of the new tag form, tag writing process is carried out through the antenna 0.

2.5.2. Tag Read Form

Tag reading process is accomplished by a function named "Show ()" with the timer function. Function takes an array and receives a list of tags that have been stored in the memory of the reader. The tag information is received to an array as converted to binary digits with specific functions. The control is done with determined code to avoid confusion with other RFID tags. All information on the tag is pulled from the database. Finally, the display screen is cleared whenever a new tag comes.

Fuel and plate information are obtained by converting the textual statement of incoming hexadecimal information from tag in the tag reading process. The function that performs this conversion;

```
public string ConvertHexToString(String HexValue)
{

            string donus2 = null;
            string hexValues = HexValue;
            string[] hexValuesSplit =
hexValues.Split(' ');
            foreach (String hex in hexValuesSplit)
            {

                int value = Convert.ToInt32(hex,
16);

                string stringValue =
Char.ConvertFromUtf32(value);
                char charValue = (char)value;
                if (donus2 == null)
                    donus2 = charValue.ToString();
                else
                    donus2 = donus2 + ' ' +
charValue;
            }
            return donus2;
}
```

During the process of loading tag reading form, the information from number 1, 2, and 3 antennas are read by connection.

```
rFuelConnect.okuyucuBaglanti();
rFuelConnect.mReader.AntennaSequence = "1,2,3";
rFuelConnect.mReader.ClearTagList();
```

Tag reading form is shown in Figure 13.

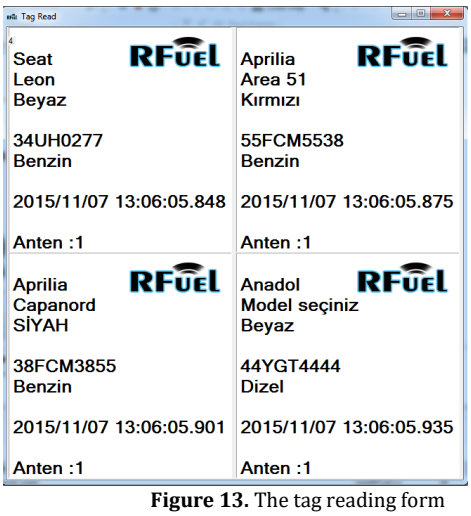

Figure 13. The tag reading form

2.5.3. Tag Editting Form

Primarily the existing information in tag is displayed by clicking to the read button on the form. Read process occurs as in the form of tag reading and information is displayed in the labels in the "Tag Information" group. Update button is clicked after taking the necessary corrections. The update process is similar to the writing process. The only difference is the database command.

Establishing a connection with the reader during the loading of the new tag form, tag writing process is carried out through the antenna 0.

```
rFuelConnect.okuyucuBaglanti();
rFuelConnect.mReader.AntennaSequence = "0";
```

Tag update form is shown in Figure 14.

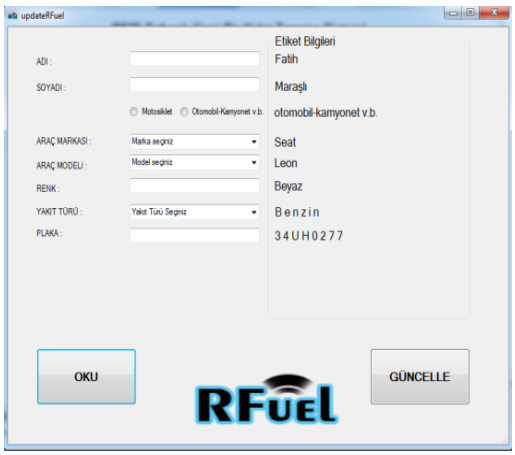

Figure 14. The tag updating form

2.5.4. Field Application

The equipment used in the fuel identification system was placed at a petrol station in the city of Ahlat in Bitlis on 03.11.2015 for testing purposes in the fieldwork of the project. The arrival time of the vehicle to the station is shown in Figure 15.

Figure 15. The arrival vehicle

Antenna, sending a signal to the tag, activates the tag when the vehicle arrives at the station. Tag sends the existing knowledge to antenna on itself. Tag was placed in a point that will see the vehicle at station as shown in Figure 16.

Figure 16. Antenna location

The information read by the antenna is sent to the reader and the information received from the reader is displayed in the program interface with the necessary base transformations. The results in reading interface are shown in Figure 17.

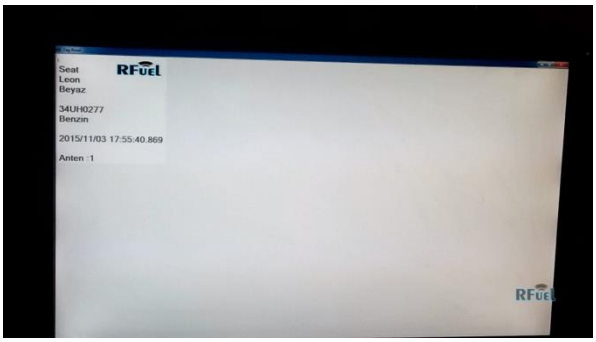

Figure 17. Result of the tag reading form

The main interface of the program is open on the computer at the same time while the tag reading form is displayed on a different monitor. It is available to read interface on a screen on the running system with dual screen and is available to main interface of program on the other screen as shown in Figure 18. In this way, Readings from the other antenna can be showed the located monitor outside while tag fixes and new tag identification can be performed with a specified antenna the main computer screen inside. Thus, a separate reader is not needed for each process.

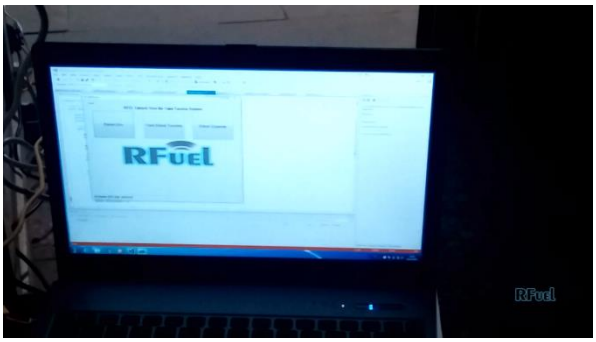

Figure 18. The main form of program

3. Results and Discussion

As wireless systems are developing, many solutions for problems are found and areas of usage are increasing day by day. In this case, RFID systems which are flexible, reliable, low expenditure, practical, can be integrated with many wireless systems, will have big contribution.

Widespread studies on improving the capacity of RFID are being maintained. Magnetic RAM or MRAM stores information with magnetic bits arrays whose sizes are nano [11]. Writing about MRAM means that changing the magnetic poles of each bit and hiding this value without power requirement. Future applications of nanotechnology will be able to eliminate the need for silicon chip by enabling ink-based RFID circuit. The best example is a prototype organic IDs developed from ink completely [12] and its cost is under 0.01 dollars. Organic ID is expected to be popular among 5-10 year [13].

According to surveys, day by day, the position of RFID systems in market and its rising graphic shows that it will be solution for many problems. In this process, the developers begin using RFID in different fields and the

system is optimized intended for need. In this way, big work can be done with a small system is shown. However, in the project security problems are taken place by increasing information flow. In that regard, various security algorithms are being developed [14].

According to the results of mini-survey on necessity of this working, it is concluded that financial damage and loss in value because of improper filling of fuel in the stations are in different dimensions in a year. This financial loss might be a tank of gas's price as a minimum, and renewal cost of vehicle's engine as a maximum. Besides customers' loss of station gives major damage if we look at graphics showing up according to result of survey, it is reached a conclusion that the harm happened by multiplying wrong filling number in a year with cost can be more than price given to system just only once Demand of stations for these systems can also be seen at ratio of 96%. Judging the state of development of the study, when the system is integrated with cash register, there will be no necessity of pump officers' entering the plate number so different plate inputs will be prevented. The information obtained from the study being kept in the database, if requested, can be used for some applications. In the case of spreading of the study, with this information will be obtained, it can be reached the opportunity of having statistical information about wrong filling of fuel in the country.

Another important benefit of the study is to prevent loss of time which a pomp officer comes across while obtaining of information about the vehicle. In this way, the contributions to operation performance of the fuel filling staff will be inevitable

Acknowledgements

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