

## Monitoring and Control the Supply of Fuel in Baghdad using RFID

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**Abstract** Nowadays, there are no accurate records of the various quantities of fuel being dispensed at the Iraqi fuel stations. All such reports are usually paper-based and are missing the required precision to control this valuable commodity, which could lead to misuse or illegal sale of fuel. This paper presents a control system based on RFID technology to monitor the supply and dispensing of vehicle fuel in Baghdad. The system consists of RFID readers attached to fuel dispensers and pumps, and RFID tags assigned to the vehicles and the trucks used for delivering fuel to the fuel stations. A hardware part is connected to conventional fuel dispensers and machines, located at both the stations and the fuel refineries or depots, which makes them work under the control of the RFID system, without the need to rebuild new dispensers. The designed system database is a centralized one located on a cloud server, in order to allow fuel stations to communicate with it and do the required transactions. Throughout this system, different reports can be generated, which can give important online statistics about the movement of fuel supplies over the city.

**Index Terms**— Fuel distribution, Fuel stations monitoring, Fuel supply control, RFID

### I. INTRODUCTION

At present, fuel stations are operated manually, which are time consuming and require more manpower. To place fuel stations in distant area, it's very costly to provide excellent services to the consumers [1]. Fuel stations companies are frequently hard to manage. Often, there is no staff on site to manage who is accessing the fuel, for what purposes, so that typically up to about 30 percent of the fuel used every month is simply unaccounted for [2]. Enterprises engaged in urban and suburban public transports, as well as other transport enterprises, big fuel consumers, need control of fuel delivery to prevent and or, at least, minimize misuse of fuel dispensing [3].

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 led to many accumulated complication factors in Iraq [4]. There are no precise statistics about delivered, dispensed, and remained quantities of fuel at Iraqi fuel stations.

Unauthorized sell of fuel, or fuel smuggling could happen in accordance with that.

Monitoring of fuel is not easy; since the fuel goes through different stages till reaching the tanks of vehicles. The major monitoring can be done at the fuel stations; which could reduce the effort taken for keeping track of the quantities of the fuel.

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 [5].

Car networking applications in the transportation industry have become more and more deep. Along with the network popularization, make it become an important part of transportation industry of the Internet of things [6]. So, this system can be considered as one of such applications, which intends to improve fuel dispensing industry.

RFID-based systems move beyond detection and identification to become tracking systems that combine security with more efficient tracking

of vehicles throughout the industrial sector, including much easier and faster identification of the vehicles [7]. The rising use of RFID has been stimulating the world market through strong financial investments heading for the adoption of RFID as a standard identification technology [8]. This paper introduces a procedure for controlling the supplies of fuel in an efficient way using RFID technology in the city of Baghdad.

## II. SYSTEM DESIGN

Until only recently, the trucks were tracked manually, and security was one of the company's greatest concerns. With the high price of fuel, a portion of a truck fuel was often stolen before a delivery truck reached its destination in the fuel station [9].

The first step of monitoring is to count the liters of fuel transported by fuel trucks and being discharged in the storage tanks of the fuel stations. Then, the total quantity of the discharged fuel is stored in the system database, so that all the fueling processes will be done by referring to this figure. This can be done based on RFID technology.

The trucks assigned to this job system are supplied with RFID tags so as the discharging operations to those trucks will be done regarding this ID. Also, each vehicle will be registered and will receive an RFID tag. The unique ID of every tag identifies each registered vehicle and it is stored in the system database with specific information about this vehicle. Upon registration, every vehicle within the system will be assigned a total quota of fuel depending on the money being paid. The process of registering fuel stations, depots, trucks, vehicles and customers can be

done through an application software with multiple forms dedicated for this purpose.

The RFID readers, used to identify the vehicles and trucks tags, will be installed at the fuel stations as well as at fuel depots. These depots and fuel stations have connections to the central database of the system as depicted in Fig. 1. In the fueling operation, each time a reader gets the ID of a tag, the related quantity of fuel will be available to be dispensed. After that, a complete record, including the vehicle information, fuel station that dispensed the fuel, and the amount of the fuel dispensed, will be stored in the database of the system. For the discharging operation at the depots, when a reader gets the ID of a truck's tag, fuel will be supplied to the related truck. Then, another record will be saved in the system database concerning such operations.

If there is no adequate quantity of fuel, in the storage tanks of a fuel station, dispensing from this station will stop and vehicles cannot fuel from this station. A necessary action has to be taken before this station can get back to serve again.

At properly chosen periods of time, important reports can be generated regarding all fueling processes. This gives comprehensive records about the various quantities of fuel being supplied and helps improving the related procedures to better select the effective way(s) for distribution and dispensing of fuel. Through these reports, any possible fraud can be detected and variations in the quantities supplied can be monitored as well. Thus, preventing or at least minimizing illegal fuel smuggling or sell.

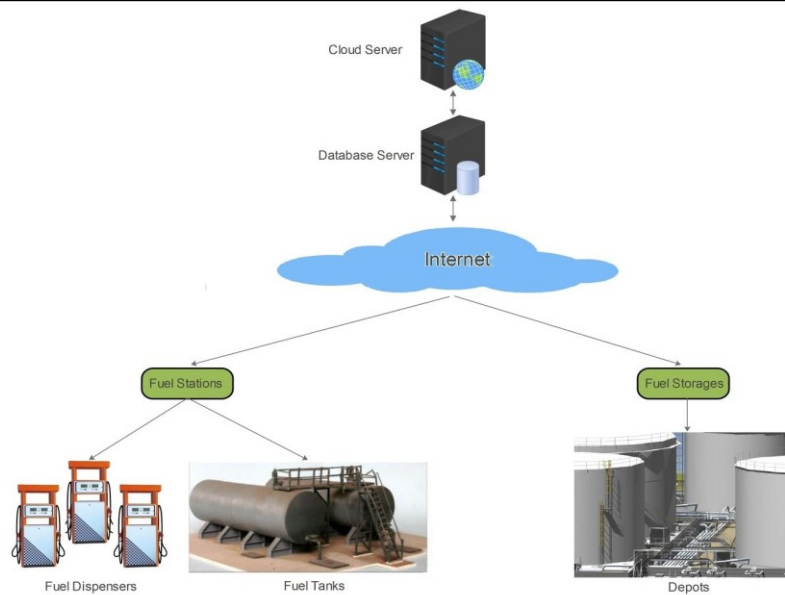


Fig. 1. System architecture

### A. RFID

Radio frequency identification is a generic term that is used to describe a system that transmits the identity of an object or person wirelessly, in the form of a unique serial number, by using radio waves [10]. The RFID system of Fig. 2 is composed of the following elements [11]:

- An integrated circuit (a microchip), which contains the data of the element to identify;
- An antenna used to transmit signals between the reader and the RFID tag;
- A reader, which receives signals from the RFID and is responsible for processing

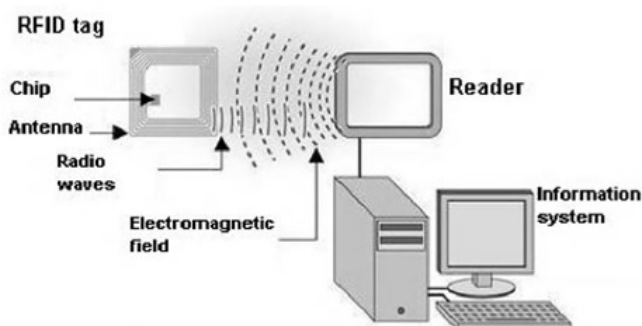


Fig. 2. RFID system [11]

### B. System Database

Design of fuel dispensing and distribution system based on RFID technology needs to implement database in order to collect all

information related to the system. An adequate database for such application is the MySQL database. It is a centralized database located on a cloud server, which allows access to the database from different city locations. Fuel stations and depots within the same area can be connected to local servers in order to enhance the recording process. Therefore, the software application of the system needs only a fast internet connection for communicating with that server.

Records related to fueling operations monitored by the presented system are stored in dedicated tables in the system database; to prevent any conflict records and ensure proper retrieving of information in order to generate the required reports of tracking.

Cloud databases provide scalability, high availability, optimized resource allocation and multi-tenancy [13]. Using a unified cloud database empowers a single authentication system to more effectively manage pricing, events, reduces inventory losses, expands service offerings, and provides entire RFID infrastructures using a single system [14].

### C. Fuel Dispenser Embedded System

Before this system can be implemented, an intensive study on the operation of fuel dispensers and dispensing pumps was performed, in order to utilize RFID in this operation appropriately. A typical fuel dispenser consists of two main parts;

mechanical and electronic. The electronic part is an embedded system (CPU) that controls the dispenser and it has a micro switch, (a rotary industrial encoder traditionally named pulser), a card relay, a keypad, a display, and solenoid valves [4].

In this system, the embedded systems of conventional fuel dispensers at stations can be adapted so as to make them work under the control of RFID technology and the hardware system designed for this purpose. All signals sent by that embedded system are redirected and maintained by the new system. The same thing is true for the dispensers that supply the fuel to the trucks, which transport fuel to the stations, i.e. a hardware system is used to control signals used to operate those machines and pumps.

This procedure can save costs and is considered a very efficient way in the implementation of RFID in fuel supply in Baghdad without the need to build new dispensers based on that technology; since there are so many conventional fuel dispensers operating in the Iraqi fuel stations.

### III. SYSTEM OPERATION

Crude oil is refined and purified at the refineries in order to produce various petroleum products. Then, these products will be stored at depots inside or outside the refinery. Every depot is assigned with a unique ID stored in the system database. When the refined fuel flows through the pipes, fuel meters measure the flowing fuel discharged in this dedicated store and the counted liters will be stored in the DB. So, the system has an entire overview on the quantities of fuel in the depots before this fuel is transported to the fuel stations in order to be dispensed to vehicles. Hence, the system can be divided into two tracking procedures; tracking of fuel trucks that transport the fuel, and monitoring the various quantities of fuel at the fuel stations.

#### A. Tracking of the Transport Trucks

The fuel produced in the refineries or stocked in the storage tanks or depots need to be transported to fuel stations in order to be supplied to the vehicles, so that fuel trucks are used for this purpose. Each truck is equipped with an RFID

tag, which has a unique ID stored in the system database with related information, about the truck, required by the system.

Before filling a truck with the fuel, its tag ID is scanned by RFID reader located on site. A flow meter measures the liters discharged in this truck. Then, a full record about this operation is stored in the database, including the driver name, plate number, and the quantity of the loaded liters, as well as the related tag ID. Therefore, the system has complete monitoring on this truck and its load capacity.

At the fuel station, a reader gets the ID of this truck, so that the fuel is ready to be discharged in the storage tanks of that fuel station. This information is also stored in the database. Then, as the system uses a unified cloud database, the two quantities of fuel, regarding processes of charging and discharging, are compared together, if the difference is more than a predefined value, say twenty liters, the system points out this variance to the system administrator in order to take the required action. So that the system can observe fuel transferred by these trucks and can put a stop to possible fuel smuggling.

#### B. Monitoring Fuel at Stations

When a fuel truck discharges fuel in the storage tanks of a fuel station, this quantity will be added to the total amount of liters stockpiled there, so as all fueling operations will be done with respect to this quantity.

Vehicles can fuel from different fuel stations, as long as these stations are registered in this system. Then, every fueling operation will be recorded in the database of the system, with data needed in this action. This helps the system to compute the dispensed amounts of fuel and compare them with the total quantity available for this fuel station and ensures fueling within that amount.

As compared with paper-based reports collected daily regarding the quantities of fuel, this system is considered an efficient way in accounting for these quantities and gives accurate statistics, the simulation results are shown in the next section. This enables to have absolute control over fuel and prevents any kind of fraud or illegal sell of fuel. Fig. 3 illustrates the main proposed monitoring procedure of the system.

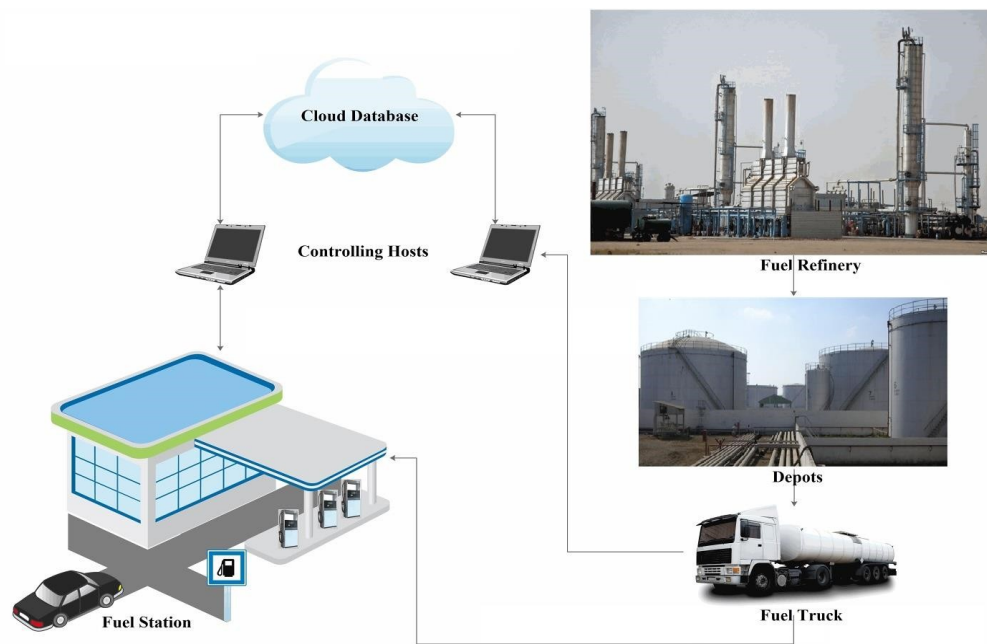


Fig. 3. Proposed monitoring system procedure

**IV. RESULTS AND DISCUSSION**

The operation of the presented system is divided into two main parts. The first part is to monitor trucks that transport the fuel from depots to the fuel stations. Each truck is supplied with a unique tag ID stored in the DB with information concerning the truck. As the reader of the depot detects a tag ID of a truck, the system will be ready to discharge fuel to the tank of this truck.

The figure for the total quantity of fuel in the storage tank of the depot is stored in the database. The pulse of the fuel meter which counts the supplied fuel to the fuel trucks is controlled by the hardware system that processes the pulse signal so that the counted liters can be measured by the system and stored in the database.

The total quantity stocked in the related fuel storage is updated in the database so, this quantity is detected by the system in order to control the supplied fuel to the truck and ensure the availability of fuel in the storage tanks.

A full record is also stored in the database concerning this operation with information about the truck that transports the fuel. Table 1 shows a sample of such information.

When this truck reaches its destination at the assigned fuel station, the RFID reader of the station storage tank reads and makes record of the tag ID of the truck before allowing fuel discharge. This quantity will be added to the total stocked fuel in the tank, and should match the capacity of fuel already supplied to the truck.

TABLE 1. INFORMATION RECORD OF THE FUEL TRUCKS

Tag ID	Plate number	Driver name	Supplied fuel [ltr.]	Depot ID	Date	Time	Destination 1	Destination 2
E83C030123A6D1000	56770 B	Ahmed Qasim Esam	35,933	A1	26/7/2015	6:46:13	Saydiah Fuel Station	Null
E83C030123A6D1102	99112 A	Saad Ali Mohammed	33,897	B5	29/7/2015	6:58:23	Kaylani Fuel Station	Null
E83C030123A6D1014	83324 S	Fadhil Taha Rasheed	26,966	C3	5/8/2015	7:02:03	Saadoun Fuel Station	Null
E83C030123A6D1006	78101 J	Ehsan Yassir Thamer	30,667	D4	10/8/2015	6:52:26	Hurriyah Fuel Station	Null
E83C030123A6D1108	45090 B	Usama Habeeb Jasim	30,000	A2	12/8/2015	6:48:10	Bayaa Fuel Station	Null
E83C030123A6D1010	22170 F	Mohammed Redha Ali	43,334	A3	16/8/2015	6:28:41	Mansour Fuel Station	Risalah Fuel Station
E83C030123A6D1105	13101 M	Ammar Jaleel Ismaeel	20,667	B3	17/8/2015	7:09:31	Alameen Fuel Station	Null

In the second section, a hardware system which is used to control the fuel dispensers is discussed. It consists of a microcontroller, relays, LCD, and other basic electrical components. This system has the full control on the signals that are used to operate the fuel dispenser, and is considered as the new embedded system of this dispenser. Fig. 4 shows the hardware system block diagram for dispensers and pumps at both the fuel stations and depots.

This hardware section is used to upgrade the operation of conventional fuel dispensers by processing and redirecting all related signals sent by fuel dispenser internal components which include the rotary encoder pulser, relays, and micro-switch. When a valid RFID tag is detected and related balance is retrieved, the host computer sends the required signal to the microcontroller, which enables those controlled signals to operate the related fuel pump or dispenser. At the end of the fueling operation, the microcontroller disables the operating signals and set the dispenser to idle state.

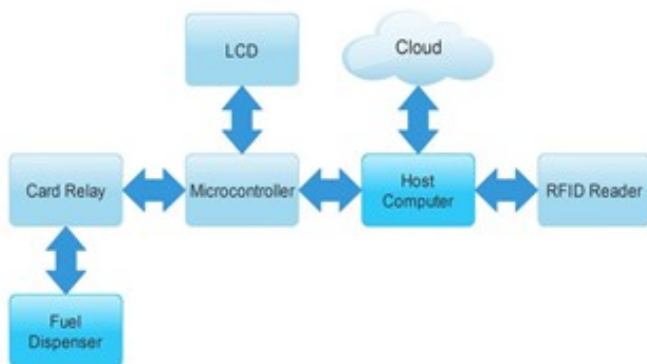


Fig. 4. The hardware system block diagram

As a practical adaptation of this system, a connection to a fuel dispenser at a fuel station was done in the city of Baghdad, and related results were obtained (illustrated in the tables below, Table 2 and Table 3). Fig. 5 shows the locations of the main fuel stations in the city of Baghdad.

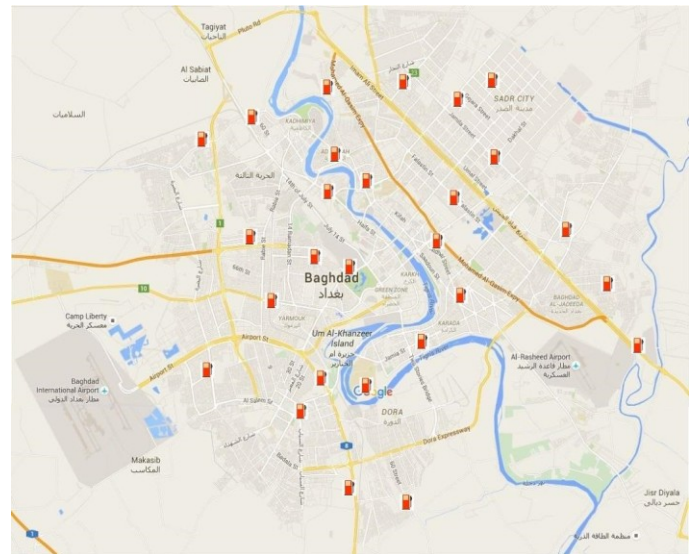


Fig. 5. Locations of the main fuel stations in the city of Baghdad

When a registered vehicle reaches the dispensing pump, this pump will not work unless there is a valid RFID tag related to that vehicle. After checking the authority of this tag, the related balance, dedicated quantity of fuel, will be available to be dispensed. At the end of the fueling operation, a full record will be stored in the database of the system concerning this process with information about the vehicle being supplied with the fuel and about the fuel station, including the station name, location, and region, as well as the dispensing pump that supplied the fuel. Through this procedure, all records of the fueling operations will be stored and tracked, and all the quantities of the dispensed fuel from all fuel stations in a certain city can be accounted for.

In case a vehicle gets stolen, it will be set by the system as an unauthorized vehicle. Once it is detected by an RFID reader of any fuel dispenser, the system will not enable the operation of this dispenser and will monitor this vehicle to the administrator through a warning message in order to take the necessary action.

The operation of conventional fuel stations has many disadvantages compared to the presented system. At the existing stations, fuel is discharged in the storage tanks of the station and counted by flow meters attached to these tanks. Then, the station manager records the hidden counter of each fuel dispensing pump before the

dispenser's attendant, the worker, takes charge of this dispenser.

At the end of the worker shift on this dispenser, the hidden counter will be recorded again, and the difference between the two counters' readings is the liters dispensed by this dispensing pump, so that the worker has to pay the related money regarding this assigned quantity of fuel. The manager then deposits the collected money in the bank account of the Ministry of Oil, and informs the distribution section about the remaining and needed quantities of fuel to be supplied to the station in the next day.

All such procedures can be eliminated by implementing the proposed system, as the system records every single fueling process and keeps track of the dispensed quantities of fuel from fuel stations. The system can also monitor and observe the quantities of fuel transported by transport trucks and delivered to the fuel stations. The remainder of the fuel represents the difference between the supplied and delivered quantities of fuel registered by the system. Thus, all the quantities of fuel that are being supplied or delivered or remained, are tracked by the system in order to control these products. Tables 2 and 3 show samples of the two forms concerning dispensing operations and data collection.

TABLE 2. DETAILS OF FUEL SUPPLY OPERATION

Card ID	Vehicle brand	Vehicle color	Vehicle type	Plate number	Amount dispensed	Date	Time	Station name	Region
F83C030123A6D9027	Chevrolet Tahoe	Green	Private	12879 B	17.28	16/7/2015	0:47:42	Mansour Fuel Station	Karkh
F83C030123A6D9015	Peugeot Roa	Green	Others	66554 S	28.13	16/7/2015	0:47:52	Mansour Fuel Station	Karkh
F83C030123A6D9010	Mitsubishi Lancer	Red	Private	42221 A	15.86	16/7/2015	0:52:06	Mansour Fuel Station	Karkh
F83C030123A6D9025	Saba Saipa	Yellow	Taxi	10981 B	13.94	14/8/2015	12:12:20	Hurriyah Fuel Station	Rusafa
F83C030123A6D9028	Hyundai Accent	Black	Private	54011 R	21.989	14/8/2015	12:18:17	Hurriyah Fuel Station	Rusafa
F83C030123A6D9013	Nissan Versa	White	Private	54332 R	21.07	14/8/2015	12:18:46	Hurriyah Fuel Station	Rusafa
F83C030123A6D9005	Hyundai Accent	Black	Private	83213 D	13.16	14/8/2015	12:22:30	Hurriyah Fuel Station	Rusafa
F83C030123A6D9010	Mitsubishi Lancer	Red	Private	42221 A	17.1	7/9/2015	20:48:19	Kaylani Fuel Station	Rusafa
F83C030123A6D9012	Toyota Camry	Green	Private	33344 C	10	7/9/2015	20:49:33	Kaylani Fuel Station	Rusafa
F83C030123A6D9029	Ford Focus	Blue	Private	70011 A	17.55	7/9/2015	20:52:15	Kaylani Fuel Station	Rusafa
F83C030123A6D9001	Dodge Avenger	Yellow	Taxi	89981 A	0	7/9/2015	20:54:21	Kaylani Fuel Station	Rusafa
F83C030123A6D9000	Nissan Sunny	White	Private	56870 D	23.45	7/9/2015	20:59:24	Kaylani Fuel Station	Rusafa
F83C030123A6D9026	Hyundai Sonata	Red	Private	21868 S	10.55	4/10/2015	15:10:25	Saydah Fuel Station	Karkh
F83C030123A6D9016	Hyundai Elantra	Red	Private	98976 C	21.5	4/10/2015	15:13:22	Saydah Fuel Station	Karkh
F83C030123A6D9006	Jeep Liberty	Grey	Private	89832 D	33.36	4/10/2015	15:15:23	Saydah Fuel Station	Karkh
F83C030123A6D9002	Daewoo Nubira	White	Private	23322 R	18.08	4/10/2015	15:16:33	Saydah Fuel Station	Karkh

TABLE 3. TYPICAL STATISTICAL RECORDS OF FUEL STATIONS

Station name	Location	Region	Amount dispensed	Date	Time	Dispenser ID
Mansour Fuel Station	Al-Mansour Dist.	Karkh	17.28	16/7/2015	0:47:42	D 1
Mansour Fuel Station	Al-Mansour Dist.	Karkh	28.13	16/7/2015	0:47:52	D 2
Mansour Fuel Station	Al-Mansour Dist.	Karkh	15.86	16/7/2015	0:52:06	D 7
Hurriyah Fuel Station	Al-Karradah	Rusafa	13.94	14/8/2015	12:12:20	D 5
Hurriyah Fuel Station	Al-Karradah	Rusafa	21.989	14/8/2015	12:18:17	D 14

Hurriyah Fuel Station	Al-Karradah	Rusafa	21.07	14/8/2015	12:18:46	D 9
Hurriyah Fuel Station	Al-Karradah	Rusafa	13.16	14/8/2015	12:22:30	D 2
Kaylani Fuel Station	Al-Baab Al-Sharqi	Rusafa	17.1	7/9/2015	20:48:19	D 4
Kaylani Fuel Station	Al-Baab Al-Sharqi	Rusafa	10	7/9/2015	20:49:33	D 12
Kaylani Fuel Station	Al-Baab Al-Sharqi	Rusafa	17.55	7/9/2015	20:52:15	D 18
Kaylani Fuel Station	Al-Baab Al-Sharqi	Rusafa	0	7/9/2015	20:54:21	D 8
Kaylani Fuel Station	Al-Baab Al-Sharqi	Rusafa	23.45	7/9/2015	20:59:24	D 11
Saydiah Fuel Station	Al-Saydiah	Karkh	10.55	4/10/2015	15:10:25	D 1
Saydiah Fuel Station	Al-Saydiah	Karkh	21.5	4/10/2015	15:13:22	D 6
Saydiah Fuel Station	Al-Saydiah	Karkh	33.36	4/10/2015	15:15:23	D 19
Saydiah Fuel Station	Al-Saydiah	Karkh	18.08	4/10/2015	15:16:33	D 3

## V. CONCLUSION

The presented strategy in this paper shows that complete fuel dispensing data can be acquired and monitored with full details. Hence, several parameters which are involved in the processes of fuel distribution in the city can be monitored and accounted for. This can be very helpful in creating some tracking reports and other useful reports, concerning fuel stations and the fuel dispensed from these stations, which can be utilized in rationing quantities of the fuel. The proposed system can also monitor trucks that transport the fuel and the quantities being transported. As the system registers all vehicles with their information, fuel will only be dispensed to these assigned vehicles in the city under consideration.

With the help of RFID technology, the system is able to keep an eye on fuel quantities and operations concerning discharging and distribution of these quantities. Thus, preventing any attempt of fuel smuggling or illegal sell. The system also reflects the power of using RFID as the only identification technology presented in this application, without the need to further technologies that require further equipment to be installed, which can raise the implementation cost.

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