Real Time Radio Frequency Identification Vehicles
Data Logger Traffic Management System

1Razan. H. Hiasat, 2Abed Almohdi Almomani
1 Computer System Engineering Department, Faculty of Engineering, Al-Balqa Applied University, Al Salt, Jordan
2 Computer Engineering Department, Faculty of Engineering, Yarmouk University, Irbid, Jordan

ABSTRACT
This paper presents a traffic management system that combines RFID and GSM technologies which they are considered to be two of the currently fastest growing technologies, RFID technology which provide a reliable data reading without the need for line-of-sight that other data detecting technologies depend on. While GSM is an open digital cellular technology used for transmitting mobile voice and data services. The system provides a real-time data detection and notification mechanism to detect traffic speed violation, also to notify the police and the car owner of the committed violation in order to be able to take the right procedure at the right time, resulting in an increasing rate of saved lives.

Keywords: Intelligent road traffic management and detection, Radio frequency identification RFID, passive tags, Global System for Mobile communications (GSM).

1. INTRODUCTION
Road traffic crashes are a major cause of death and disability. Each year almost 1.2 million people lost their lives and between 20 and 50 million people are injured or disabled worldwide as a result of road traffic crashes. [1]

Driver's behavior combined with one of the other three factors was involved in over 95% of vehicle accidents: Drivers always try to blame road conditions, equipment failure, or other drivers for those accidents. However, the behavior of the implicated driver is usually the primary cause. Speeding is a deliberate and calculated behavior where the driver was aware of the risk but ignores the danger. Fully 90% of all licensed drivers speed at some point in their driving career; 75% admit to committing this offense regularly. [2]

High speed reduces the possibility to respond in time when necessary, people need time to process information and to decide whether or not to react and finally to execute a reaction. At high speed the distance covered in this period is longer. At high speeds the distance between starting to brake and a complete stand still is longer as well. The braking distance is proportional to the square of speed \(v^2\). Therefore, the possibility to avoid a collision becomes smaller as speed increases.

As a result interventions aimed at reducing traffic speed are considered essential to prevent road injuries and to reduce the number of its victims, especially with the overwhelming increase in the number of vehicles on the roads worldwide due to the rapid development of society. [3][4][5]

Traffic management poses many critical challenges in most modern cities, including congestion, traffic violations, car theft, and illegal vehicles. Such Traffic laws were founded to govern traffic also regulate vehicles, and to facilitate the orderly and timely flow of vehicles. [6][7]

During the past few years, many researchers have addressed traffic problems, attempted to model driver behavior and to analyze the dynamic interaction between several factors influencing the driver behavior. Some researchers used Simulations of organized traffic; that involved queuing theory, stochastic processes and equations of mathematical physics applied to traffic flow; in an attempt to provide efficient traffic management algorithms. [7] [8]

Meanwhile, other researchers incorporated improved sensing and communication technologies in various intelligent transportation systems to provide users with significantly better information about their surrounding environment and the road. Some studies have used GPS, radar sensors, or digital cameras to measure average car speed and maximum flow on a road in order to determine whether a driver is over the speed limit or to provide traffic information to remind drivers to avoid congestion.[9] [10]

Currently, a considerable amount of human effort and time is spent on the calibration of operations of Large Scale Traffic Control Systems (LSTCSs).It is believed that by providing the driver with information, warning, and operational support, an Advanced Driving Assistance System (ADAS) can significantly improve driving safety.[11][12]

For the past decades, many algorithms and procedures have been developed for vehicle passage time estimation using spatial vehicle data, including those that are based on vehicle license plate numbers, vehicle shapes, and data from conventional loop detectors. [13]
A large number of systems that employed such algorithms and many other technologies to address traffic issues, such as the Intelligent Transportation Systems (ITS), Vehicle Identification System (VIS), traffic monitoring system based on real-time image tracking system, monitoring and reporting of traffic rules violation using microcontroller through wireless communication system, road-traffic monitoring by knowledge-driven static and dynamic image analysis system, monitoring and reporting of traffic rules violation using microcontroller through wireless communication system, a computationally efficient Collision Early-Warning System (CLEWS), plus countless other camera based systems, despite that the camera allows active recognition of traffic signs such a system can be a valuable addition to vision-based driver-assistance systems. However, to provide a useful system for the driver, the system has to be very robust with very low error rate, even under difficult conditions. [9][14...18][19]

Although there is a general consensus about the role that such systems may play in reducing traffic, they are not necessarily guaranteed to succeed in reducing congestion and providing a noticeable solution to traffic problems [20].

One particular growing technology offered a significant system, addressing the management and detection for traffic was proposed in Intelligent Traffic Management Expert System (ITMES), the main functions of the system are to trace criminal vehicles and to help the police if a car owner has not paid vehicle tax, license tax, or tickets. It also collects and calculates average speed moreover the maximum flow of a section of road in a city area. Thus, a dynamic guided system can use the information provided by ITMES to find a path that avoids traffic congestion. [10]

The idea that was proposed in ITMES provides a cost-efficient method that can’t be detected and avoided by careless drivers. However real-time notification of certain violations such as speed limit violation could be used as a safety measurement to decrease the number of accidents when stopping a dangerously speeding car can help in reducing the number of lives lost in accidents caused by such violations using law enforcement at the right time, although CLEWS provided such notification, but it did not cover the violations detection since it focused on the collision detection.

The purpose of this paper is to design and implement a system that uses potable units that contains RFID Transponders which can be positioned anywhere on the road, the real-time information that is collected are sent to the server that reside on static stationary, as well as providing the ability to send Short Message Service (SMS) to a police station or a nearby police unit using GSM to stop cars with violations that is considered to be a social hazards.

Another important feature is the ability to notify the car owner with the violation as soon as it was committed in addition to the ability to integrate the system with the E-government projects currently being developed locally in Jordan, providing the possibility of immediate salary payment for the ticket through E-Gov systems, resulting in efficient collecting policies, safer roads and an increased number of saved lives.

The rest of this paper is organized as followed: Section 2 discusses the main two technologies used in the proposed system Section 3 describes the proposed system framework. Section 4 presents the algorithms of the real time RFID vehicles data logger traffic management system, Section 5 shows the implementation of the proposed system. Section 6 covers the conclusion.

2. SYSTEM TECHNOLOGIES

The proposed system is built by using two significantly growing technologies which basics will be covered throughout this section: RFID as the main core technology for the system and GSM technology is used for the notification process.

2.1 Radio Frequency Identification (RFID)

RFID is a technology similar in theory to bar code identification. However, one of the main differences between RFID and bar code technology is RFID eliminates the need for line-of-sight reading that bar coding depends on. Also, RFID scanning can be done at greater distances than bar code scanning. High frequency RFID systems (850 MHz to 950 MHz and 2.4 GHz to 2.5 GHz) offer transmission ranges of more than 90 feet, although wavelengths in the 2.4 GHz range are absorbed by water (the human body) therefore has limitations.

2.1.1 RFID System

An RFID system consists of an antenna and a transceiver which read the radio frequency and transfer the information to a processing device, and a transponder (tag), which is an integrated circuit containing the RF circuitry and information to be transmitted.

A basic RFID system consists of three components:

a. An Antenna Or Coil Connected To A Transceiver

The antenna emits radio signals to activate the tag and to read and write data to it. Antennas are the conduits between the tag and the transceiver, which controls the system's data acquisition and communication.

Often the antenna is packaged with the transceiver and decoder to become a reader also known as interrogator, which can be configured either as a handheld or a fixed-mount device. The reader emits radio waves in ranges of anywhere from one inch to 100 feet or more, depending upon its power output and the radio frequency used. When
an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for processing.

To read tag data, readers use a tree-walking singulation algorithm, resolving possible collisions and processing responses one by one. Blocker tags may be used to prevent readers from accessing tags within an area without killing surrounding tags by means of suicide commands. These tags masquerade as valid tags but have some special properties: in particular, they may possess any identification code, and may deterministically respond to all reader queries, thus rendering them useless and thus securing the environment.

There are multiple available commercial types of RFID readers that can be categorized into: narrow, mid, and long range readers depending on their maximum reading range, Table.1. displays a comparison between a numbers of commercial RFID readers.

<table>
<thead>
<tr>
<th>Reader</th>
<th>F</th>
<th>V</th>
<th>Max Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4G Long Range RFID Reader (RFID-08I)</td>
<td>2.4 GHz</td>
<td>9-12V</td>
<td>10 to 15m</td>
</tr>
<tr>
<td>EM-ID 1m Long Range Reader (ERFID08Z)</td>
<td>125 KHz</td>
<td>12V</td>
<td>100 cm</td>
</tr>
<tr>
<td>EM-ID Long Distance RFID Reader (ERFID08Y)</td>
<td>125 KHz</td>
<td>12V</td>
<td>30cm-100cm</td>
</tr>
<tr>
<td>RFID Long Range Reader (ERFID08X)</td>
<td>125 KHz</td>
<td>12V</td>
<td>30cm-100cm</td>
</tr>
<tr>
<td>metraTecQuasarSR RFID-Reader</td>
<td>13.56 MHz</td>
<td>6.5-9 V</td>
<td>up to 15 cm</td>
</tr>
<tr>
<td>ElatecRFID Reader 125kHz/13.56MHz (HID PROX)</td>
<td>125 KHz</td>
<td>5V</td>
<td>10cm</td>
</tr>
<tr>
<td>ElatecRFID Reader 125kHz/13.56MHz (Mifare,HIDiclass,legic)</td>
<td>13.56MHz</td>
<td>5V</td>
<td>10cm</td>
</tr>
<tr>
<td>Posen HF Handheld RFID Reader</td>
<td>13.56 MHz</td>
<td>3V</td>
<td>Up to 12 cm, typically 8-10 cm</td>
</tr>
<tr>
<td>Eureka111 125Khz RFID reader</td>
<td>125 KHz</td>
<td>110/230 V (AC)</td>
<td>5cm</td>
</tr>
<tr>
<td>The Skye Module™ M4</td>
<td>13.56MHz ±7 kHz</td>
<td>5V</td>
<td>Read range 4.5cm</td>
</tr>
<tr>
<td>AA-R500 SP</td>
<td>125kHz;</td>
<td>12V</td>
<td>11.43 m</td>
</tr>
<tr>
<td>RFIDREAD-4100</td>
<td>125Khz</td>
<td>0.3-6V</td>
<td>6cm</td>
</tr>
<tr>
<td>RFIDREAD-μRW</td>
<td>125 kHz</td>
<td>0.3–6V</td>
<td>8cm</td>
</tr>
<tr>
<td>Compact Flash RFID Reader</td>
<td>13.56 MHz</td>
<td>3V</td>
<td>7.62cm</td>
</tr>
<tr>
<td>The Skye module M1 mini</td>
<td>13.56MHz</td>
<td>3.2–6V</td>
<td>3.5cm</td>
</tr>
<tr>
<td>Phidget USB RFID Reader</td>
<td>125 kHz</td>
<td>5V</td>
<td>10.16cm</td>
</tr>
</tbody>
</table>

System specifications can vary depending on the reader that is used; for example multiple tags reading, reading rate and range, meanwhile the different operating frequencies affects the system’s vulnerability to jamming.

In the proposed system prototype the Phidget USB RFID Reader was used obtaining a reading rate of 33ms, and achieved a precision up to 98% in most weather environments. However, the prototype’s reader couldn’t read multiple tags simultaneously due to the reader’s specification.[33]

Since the systems required two readers that provided an accurate reading and calculated the vehicle’s speed, it was important to know the exact reading range so that the readers won’t interfere with each other’s readings.
b. A transponder (RF tag) electronically programmed with unique information.[26]

RFID tags come in three general varieties: passive, active, or semi-passive also known as battery-assisted. Passive tags require no internal power source, thus being pure passive devices (they are only active when a reader is nearby to power them), whereas semi-passive and active tags require a power source, usually a small battery.

The tag type used in a system depends on the functionality of the tag itself, since the tag role in the proposed system is a redundant processing-free task; also the need for power-independent tag made the passive tag an ideal choice for such system.

In the prototype the tag used is a small passive tag in a size of a coin that can be attached to the front glass window of a car, but some careless drivers may try to remove or jam the tag so some laws and regulation should be issued to help in protecting the system.

2.2 Global System for Mobile Communications (GSM)

GSM is an open digital cellular technology used for transmitting mobile voice and data services. It differs from first generation wireless systems in that it uses digital technology and time division multiple access transmission methods. GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time slots. It also operates in the 900MHz and 1.8GHz bands in Europe and the 1.9GHz and 850MHz bands in the US. It supports data transfer speeds of up to 9.6 Kbit/s, allowing the transmission of basic data services such as Short Message Service (SMS).

The ubiquity of the GSM standard has been an advantage to both consumers (who benefit from the ability to roam and switch carriers without switching phones) also to network operators (who can choose equipment from any of the many vendors implementing GSM).

3. SYSTEM FRAMEWORK

The proposed system consists of a passive tag, two RFID readers, a personal computer or a portable unit with a microprocessor and a network interface, adding to a high-speed server with a database system.

In the proposed RFID system, cars are equipped with passive RFID tags. The interrogator, an antenna packaged with a transceiver and decoder (The RFID reader), emits a signal activating the RFID tag so it can read the ID stored in it to be used to identify that specific car.

Each tag imply a unique number and this number is linked to the vehicle unique license number. the readers will be placed in different places on the road, the distance between each consecutive RFID reader is previously known, so when the vehicle passes the first reader, the reader will reads its number and sends it to the data base server along with the time and the reader’s ID to identify the location. The received number is mapped to the real vehicle number in the data base. And when the vehicle passes the next reader, the difference in time between the first and second RFID reader is used to calculate the speed of vehicle, if the speed of vehicle is out of the speed limits of the specified road, a ticket will be charged to this vehicle and at the same time a message will be send to the police station and to the car’s owner for notification. (See Fig .1.)

![Fig 1: Real time RFID vehicles data logger traffic management system.](image)

The project consists of two main parts connected through a network; the client and the server.

3.1 The Client

It collects the tag ID of each passing vehicle along with the time that vehicle passed the reader, and sends it to the server program along with the reader’s ID.

The client is the part that will be placed on the road in order to detect passing cars, its primary function is to read the tags (car number) passing through the reader’s reading range and send them through the network to the server; the client stays in wait cycle until a tag enters the reading range of a reader, when a tag is detected its tag ID, the time at which the car passed the reader along with that reader’s ID is sent to the server part, once the data is sent the client returns to its wait state.

3.2 The Server

It processes and stores information that was sent by the clients in the database.

The server is responsible for checking the database periodically to find two tags with same ID to calculate the vehicle’s speed and if it doesn’t violate the limit then it must be deleted otherwise then it must be registered in the database and a message must be sent using GSM to nearest
police station to violation, and another SMS message will be sent to the car’s owner to notify him of the violation.

The server part can be considered as the main core of the project, it contains two main parts:

a. The Data Base
The data base provide the information needed by the police, such as the violations along with the time it was committed, the wanted car’s tag ID’s, the car owner’s name associated with the tag ID and the car owner’s mobile phone number for the notification process.

b. The Main Program
Most of the data processing is performed by the server program.

Once the server is started, it listens to the clients until it connects to one to receive data, when the client’s data is received, if the search is enabled the server checks if that car is wanted and raises an alarm in that case, if not the server processes the received data to detect violations, if no violation occurred the tag ID is deleted from the database and the server returns to listening to the clients, however if a violation is detected the tag ID is inserted to the database along with the time it was committed and an SMS message is sent to the car’s owner for notification, after that the server checks if that violation is considered a social hazard and if so a SMS message is sent to the police in order to stop that car, then the server returns to the listening stage.

4. SYSTEM ALGORITHMS
This section is concerned with the system’s software algorithms.

4.1 Client Algorithm
The client is the part that will be placed on the road in order to detect passing cars, its primary function is to read the tags (car number) passing through the reader’s reading range and send them through the network to the server. Fig 2 shows the client’s flow chart which explains the cycle of the client program; the client stays in wait cycle until a tag enters the reading range of a reader, when a tag is detected its tag ID, the time at which the car passed the reader along with that reader’s ID is sent to the server part, once the data is sent the client returns to its wait state.

4.2 Server Algorithm
The server part can be considered as the main core of the project, it contains two main parts:

a. The data base, which provide the information needed by the police, such as the violations along with the time it was committed, the wanted car’s tag ID’s, the car owners names associated with the tag IDs.

b. The main program, it performs most of the processing of the system, it mainly performs different tasks such as a connecting with the clients, manages the database, raises an alarm in case a wanted car passed a reader, Calculate the speed of the passing cars to detect violations, Send SMS message to both the police to stop cars with dangerous speed and to the car’s owner to notify him of the violation, and Prints the violations.

4.2.1 The Database
It consists of 6 different tables:
• Tag: it contains the Tag IDs of the passing cars.
• Cars: it associates the tag ID which indicates the car number with the Name of the car owner and it also contains the car owner’s number.
• Violate: it contains the tag IDs which violated the speed limit along with the speed and time of the violation.
• Summary: it contains the tag IDs of the violated cars and the violation count committed by this car along with its owner’s name.
• Password: it contains the password that allows authorized personnel to delete violations from the database.
• **Wanted:** it contains the tag-IDs of the police wanted cars. These tables provide the information needed by the police, in order to capture and punish violations.

### 4.2 The Main Server Program
Most of the data processing is performed by the server program, as it can be considered as the heartbeat of the system, it mainly performs five different, however related tasks:

- Connect to the clients and receive client data (uses TCP internet protocol).
- Manages the database: by adding the tags IDs of the passing cars and the time they passed the reader in order to calculate the speed, and delete the non-violating cars, if also insert the violating speed of the tags and provide the ability to search and delete records from the database.
- Detect wanted cars and raises an alarm in case it passed a reader, also provides the police with the reader number and the time it passed it.
- Calculate the speed to determine the path of the program.
- Send SMS message to the policeman in charge in order to stop the cars with dangerous speeds.
- Print the tag ID and the owner’s name of the car with the number of violation committed by the car.

In order to provide a better understanding of the server program; Fig. 3. explains the server program cycle; once the server is started, it listens to the clients until it connects to one to receive data, when the client’s data is received, if the search is enabled the server checks if that car is wanted and raises an alarm in that case, if not the server processes the received data to detect violations, if no violation occurred the tag ID is deleted from the database and the server returns to listening to the clients, however if a violation is detected the tag ID is inserted to the database along with the time it was committed and an SMS message is sent to the car’s owner for notification, after that the server checks if that violation is considered a social hazard and if so a SMS message is sent to the police in order to stop that car, then the server returns to the listening stage.

* The distance between the readers can be changed within the program.

**Fig 3:** Server program data flow

### 5. SYSTEM IMPLEMENTATION
The proposed system provides a convenient implementation, allowing the average user to easily interact with the system and to be able to use the system’s functions efficiently; this section shows the experimental execution of the system under study.

#### 5.1 The Client Implementation
In order for the system to work properly, the client has to be primary configured with the server’s address, so that data can be sent to the right address to be processed.

#### 5.2 The Server Implementation
Fig.3. shows the server’s main forum which contains 11 buttons that perform the server different tasks:
If the entered password is incorrect, the user gets three trails to write the correct password, after the third attempt the authentication window closes.

The authentication window provide the ability to change the password for the authorized personnel, however in order to change an old password, the user has to enter the old password correctly, or the old password won’t change as a security measure, if the old password is correct a notification will appear.

Once the authentication process is successfully completed the authorized user is allowed to search and delete violations directly from the main database.

The authorized user can use either the owner’s name or the car’s tag ID (car number) to search for violations.

Once the wanted violation is found it can be selected to be deleted by pressing the Del button on the lower left side.

e. The Wanted Cars button: manages the wanted cars table in the database by allowing the user to add or delete a wanted car from the database.

f. The violated cars button: Displays the violate table from the database.

g. Show Tag ID button: Displays the Tag table from the database.

h. The Summary button: Displays the summary table from the database, it also provides a facility to print the table by pressing the print button on the lower left side.

i. Cars Owner button: Displays the Cars table from the database.

j. The Exit button: Closes the application and terminates the connection with the clients.

6. CONCLUSIONS

The project uses RFID technology which is a low-cost available technology that produces effective results.

The RFID reader which is used to detect vehicle movements is small and the antenna used, is a normal wire, which:

a. makes it hard for the drivers to detect the location of the reader

b. Provide portability for the reading point, which means the ability to change the detecting point location without inflicting any extra cost.

And the main advantage the system provides is the real time notification for both the authority and the car’s owner, allowing the right action to be produced at the right
time to help reduce the number of lives lost in accidents caused by such violations.

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