

An Innovative RFID-Based Solution to Secure Parking Spots for Physically Challenged

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Abstract – Using RFID Technology is increasingly integrated in our daily life. We are presenting in this paper the secured parking spots for physically challenged “SPSPC” system implementing the RFID technology for managing parking slots of physically challenged. We demonstrated using scenarios (car with tag, car with expired date tag, car without tag) that the ‘SPSPC’ system is able to recognize not only cars equipped with tag -then send accordingly welcoming SMS -but also cars without tags by checking with a step tag fixed in the wall. Operational mode of the ‘SPSPC’ system is illustrated as well as main components, methods, snippets of code and interfaces are presented and commented. In addition, we demonstrated how the ‘SPSPC’ system is providing the tracking of people committing repetitively these violations -by reporting them to the authorities- and generating statistics on parking occupancy rates helping in providing sufficient slots.

Keywords – RFID Technology, Parking management, system design

1. Introduction

Using Radio Frequency Identification (RFID) technology is increasingly mentioned in several researches. RFID tags are implemented in nearly every industrial practices and are anticipated to be implemented everywhere on each single element.

Production, supply chain processes, transportation of goods, and tracking are main fields where RFID is applied in huge numbers [1].

Health care [2] and [3], agriculture [4], livestock [5], baggage handling [6], access control [7], libraries [8], military [9], passports [10], supply chain [11] and [12], inventory [13], aircraft industry [14], mobile payment [15] are some of RFID implementation fields [16].

Katz [17], for example reported the use of RFID technology in Museums and galleries for tracking artworks and other expensive pieces while moved from one art gallery to another. According to [18], more than 3000 universities in China have installed RFID tag readers, for student identification cards, and contactless library applications. Hospitals also started using RFID tags to track and manage assets, particularly expensive or critical items of equipment such as ventilators, electrocardiogram devices and infusion pumps as cited by [19]. Gilbert [20], reported its use in libraries for rapid location and checking of books. Additionally, we reviewed some researches related to our focus such as [21] and [22] which are proposing RFID technology for parking management. We can mention at this level that they mainly focused on monitoring access to parking which is different from our focus on parking’s slots management.

In the context of UAE, the spokesman of road and transportation authority (RTA) clearly stated: “We have received numerous complaints from physically challenged who were not able to access parking allocated to them because they were already occupied by unauthorized people”. Currently, physically challenged have to place their permission card in front of their cars and it is hard for the agents to verify their authenticity. The RTA recognized the

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need for a sophisticated information system to control the physically challenged parking slots and meet the growing demands of vital statistics. Thus, we are proposing a system taking advantage of RFID technology to provide flexible software facilitating and assisting the provision and the control of parking slots for physically challenged [23]. This system is intended to:

- Assist in minimizing these abuses that come from some individuals against this category that deserves our appreciation and care.
- Increase the social awareness, educate the public and alert the community about the seriousness of this problem.
- Increase the social interest to this category of persons which will strengthen their belonging to the community and increase their sense of responsibility.
- Increase and give accurate and relevant information to the authorities by reporting those who frequently misuse these dedicated parking and follow-up with these cases.

All these objectives that we targeted had triggered the implementation of the ‘MUAWIN’ RFID system.

2. RFID Technology Overview

Currently, RFID tags are used together with the optical barcodes in order to integrate automatic identification and tracking in to already implement optical barcode system for identification and tracking. The main attention of an RFID system is to provide precise and user-friendly operations for the business procedures and the people related to them. These systems increase performance of monitoring with less human involvement, quality control, error investigation, and decrease the number of lost articles. RFID system consists of mainly two separate system: tag and reader (figure 1). Tags resemble to the optical barcodes, which are mounted on items and which have the distinctive identification of the item. The tags principally comprise the IC chip and the antenna. The antenna exchange information with the reader using electromagnetic waves (EWs). In passive tags, which do not have power supply, antennas harvest power from the EW signals to run the tag’s on-board IC chip. The IC contains the distinctive identification number of the item. Moreover, regarding to the nature of business, tags may have capability to subsequently read and write of information. If any sensor is integrated in the tag, the IC chip communicates with sensors.

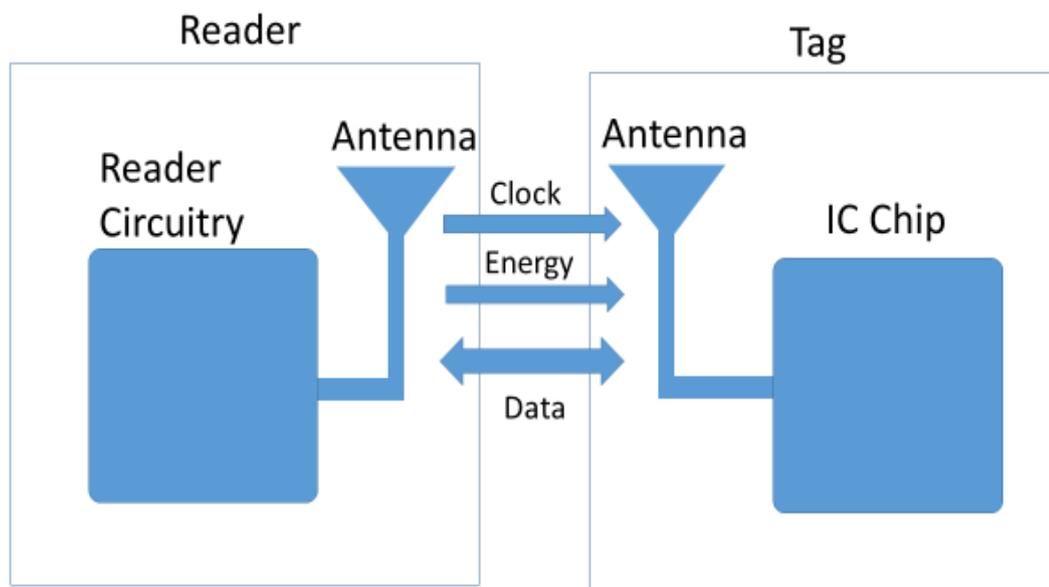


Figure 1: RFID system structure

Despite tags, readers come with many different size, shape, functionality: mobile, stationary, or handheld. Readers also have two main parts: antenna and reader circuitry. Reader antenna supplies power to tags in case of passive tags besides communicating with tags. The reader circuitry is an intermediate between the reader antenna and the IT system of the business. Reader circuitry's job is to send data through and receive data from the reader and pass it to IT system [24].

3. Summary of the 'SPSPC' RFID System

The 'SPSPC' RFID system was implemented in the objective to facilitate and assist the provision and the control of parking slots for physically challenged.

The main components of the 'SPSPC' system (see Figure 2) are as follows:

- 'SPSPC' RFID tag to be fixed in the car's front glass.
- 'SPSPC' RFID Antenna/active tag fixed in the special needs' parking sign bar.
- 'SPSPC' RFID step tag to be fixed in the floor of the parking slot to detect unauthorized parked cars which are not equipped with a 'SPSPC' Tag.

'SPSPC' RFID software that manages the reading of the tag, storing the data and sending alerts by SMS to several actors in this system: parking agents and physically challenged.

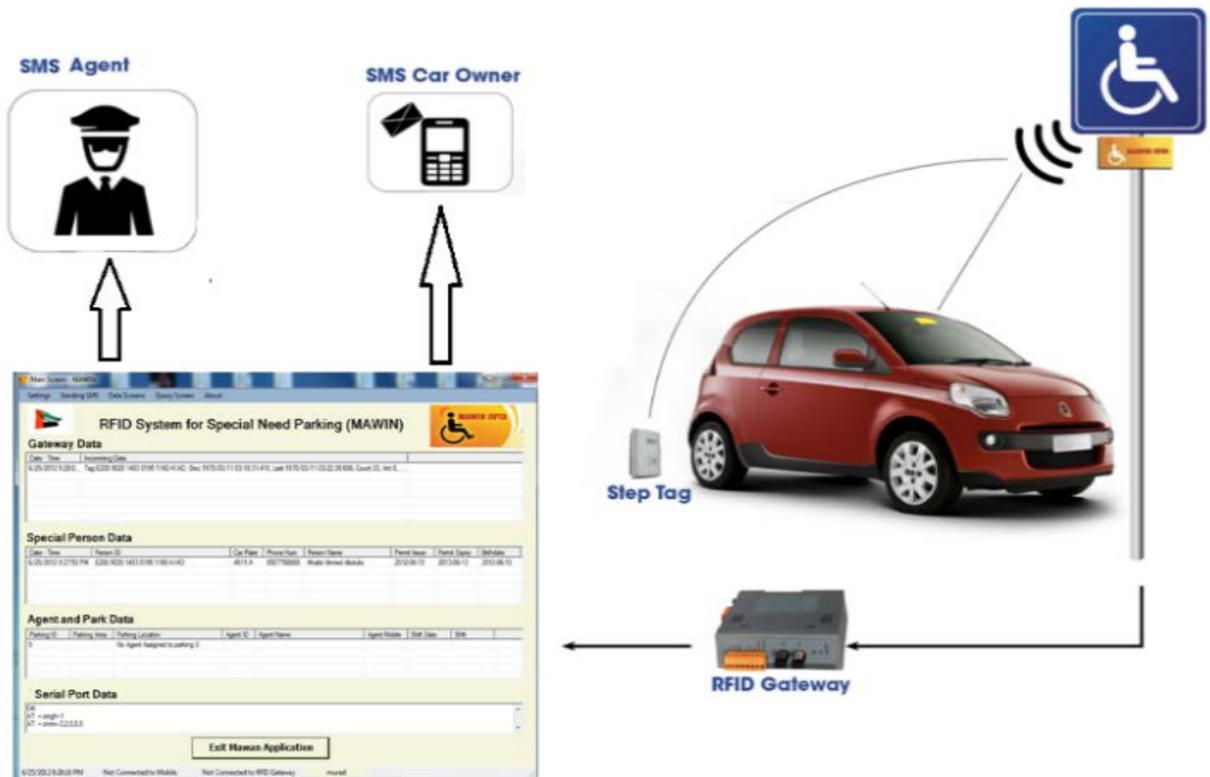


Figure 2: The 'SPSPC' RFID system operational mode

4. Method and Apparatus of the ‘SPSPC’ RFID System

The implementation of the ‘SPSPC’ system required a classical requirement gathering phase to isolate key actors of the desired information system. The discussion with special needs persons (end users), the RTA agents and the RTA information system developers (clients) led to the following entities (see Figure 3).

Special needs person: information about the tag holder (Tag_ID, Name, Car_number, Mobile_number, Expiry_date, Issue_date).

- Parking: information about the parking location (Zone, Landmark, Parking_number, Type).
- RFID sensor: information about the sensor occupation (Reader_ID).
- SMS messages: information about the SMS messages to be sent to the person (SMS text, SMS type : welcoming, warning, agent).

Agents: information about the agents (Agent_ID, Mobile_number, Shift time and L and location().

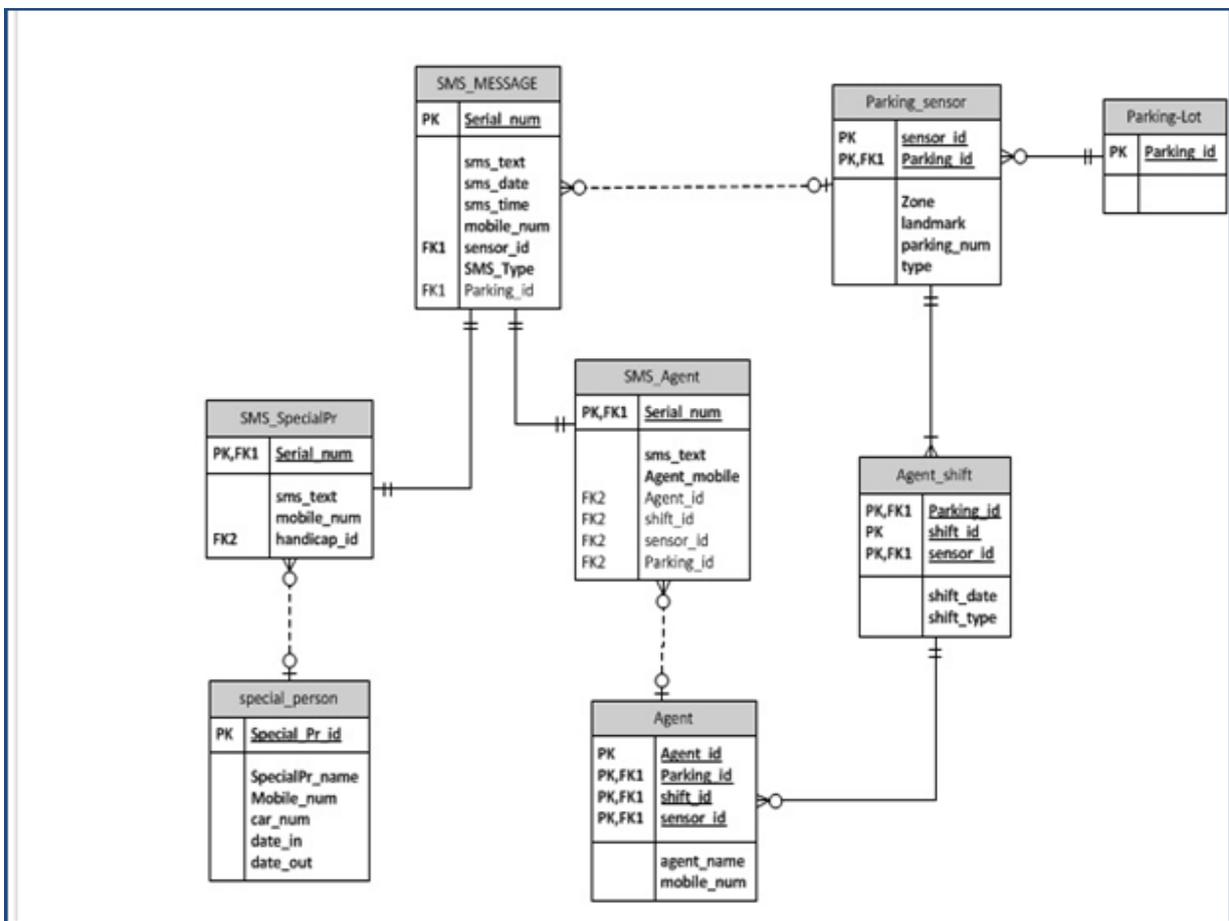


Figure 3: The Entity Relationship Diagram of the ‘SPSPC’ system

5. The ‘SPSPC’ System Architecture

We designed the ‘SPSPC’ system based on three main components:

RFID reader discovery, communication and data acquisition through the network: in the initialization phase of the application we should establish a

connection to the reader through the network as the device is directly plugged to the network so it has its own IP address. Once the connection is established, we can choose two mode of scanning either continuous scanning or scanning with a specific frequency (1 minute or more for example) between

each two readings. We chose to use the second option as it overloads less the network considering that during this minute nothing can happen. Then come the phase of Tag scanning which is mainly consists in ordering the antenna to scan the existing tags in its perimeter of action. The system will store the information of the tags that answered the antenna signal in an array TagList that we have to browse afterward to extract the data related to each tag separately.

Database access: the database access will be activated every time the system detects a tag in the area of the antenna in order to identify it and send accordingly an SMS. Every time the antenna/sensor reads a tag, the system has to compare it to the list of registered tag holders in the database and verify the validity of the tag. Dedicated forms for adding tag holders updating their information as well as agents and their information were created under this module see Figure 8. The full structure of the entities of our database is illustrated in Figure 2 .

SMS messaging: this module is used to communicate with the mobile phone connected to the computer in order to send SMS to the different actors of the system (agents, tag holders). It is also possible to perform the same task by sending SMS through Web servers to registered users. We defined three types of SMSs : 1) welcoming: for tag holders with valid tags informing them about the number of existing parking in the area, 2)warning : for tag holders with expired tags and 3) alerting : to be sent to the agent to move to a specific parking slot to give a fine as there is unauthorized car parked there. Dedicated forms were also created to send spontaneous messages to tag holders as well to analyze the cost of the sent SMSs.

6. The ‘SPSPC’ System’s Main Methods

1) Reader discovery and opening a connection through the network (see Figure 4): the RFID reader is an IP device, before each use the admin should connect to it to start reading.

Once we discover the reader through the network by providing its IP address we have to open a connection with it in order to start scanning the tags.

```
// Connect to the reader
private void
connectToReaderActionPerformed(java.awt
.event.ActionEvent evt) {
    try{
        reader.setConnection(ipaddress,
23);
        reader.setUsername(readerusername);
        reader.setPassword(readerpassword);

logArea.setText(logArea.getText()+"\nCo
nnection Successful Created");
logArea.setText(ipaddress+"\n"+readerus
ername+"\n"+readerpassword);
    } catch(Exception e){
logArea.setText(logArea.getText()+"\n
Connection Failed");
    }
}

// Open a connection with the reader
private void
openReaderActionPerformed(java.awt.even
t.ActionEvent evt) {
    try {
        reader.open();
logArea.setText(logArea.getText()+"\n
Reader is open");
logArea.setText(logArea.getText()+"\n-
- - - - -");
    } catch (Exception ex) {
logArea.setText(logArea.getText()+"\n
Reader could not be opened");
logArea.setText(logArea.getText()+"\n-
- - - - -");
    }}
}
```

Figure 4: Code snippet for connecting and opening a connection with the RFID reader

2) Scanning tags using RFID antenna (see Figure 5): each minute the antenna will scan the existing tags. In the method below we are illustrating how we gather the data from the reader in form of an array of arrays. Each element of the TagList array is including the data related to one tag (ID, RSSI, etc). So if we have many tags responding to the radio wave sent by the reader they will respond each by sending an array of data which will be consolidated by the reader in one big array which is TagList.

```

3) // Read the list of tags items
private void
scanTagActionPerformed(java.awt.event.ActionEvent evt) {
try{
    for(int i=0; i<1;i++){
        tagList = reader.getTagList();
    } catch (Exception ex) {

tagArea.setText(tagArea.getText()+"\n
Failure to load the Tag List");

tagArea.setText(tagArea.getText()+"\n
- - - - -");
    } }

```

- 4) Check 'SPSPC' step tag: This method is used to check if there is an authorized car parked in the parking slot. As any unauthorized car is not equipped with a 'SPSPC' tag, a step tag is placed in the ground. This method will check the strength of the signal of the step tag using the variable Return Signal Strength Indication (RSSI). If this variable is weaker than the normal so it means that there is an obstacle that affected it and the system will send an alerting SMS message to the agent informing him that a car without permission is parked in this specific parking slot.
- 5) Check 'SPSPC' Tag expiry date: the system will read the tag information then check if it is expired or not using the filed ExpiryDate. If the tag validity is expired then the system will send a warning SMS message to the tag holder informing him to renew his tag within 15 days.
- 6) Sending alerting SMS: once the 'SPSPC' system recognize that there is an unauthorized car parked in the parking slot this method will send an SMS to the parking agent operational at that moment by extracting his information from the time table of the agents. This message will simply include the parking slot number so he can move there and give a fine to the unauthorized parked car.

- 7) Sending welcoming SMS: once the tag is tracked by the 'SPSPC' system and the its validity is verified, this method will send a welcoming SMS to the 'SPSPC' tag holder informing him about the number of free parking slots available in this area.
- 8) Generate Statistics : the 'SPSPC' system can generate a statistical report that :
- Identify the most used parking slots.
 - Identify car plates of unauthorized people who misuse the parking slots.
 - Calculate the occupancy rate of parking slots.
 - Calculate the financial cost of parking slots' misuse.
- 9) Manage 'SPSPC' tag holders: the admin can add new 'SPSPC' tag holder by filling his information: Name, Mobile number, car plate number, date of issue of the tag. This operation should occur before distributing the tag to its holder and the information provided by admin will be stored in the database of 'SPSPC' system (see Figure 9).

7. 'SPSPC' System in Action

Scenario 1: authorized car is parked

Any car equipped with 'SPSPC' tag will be scanned by the reader and recognized by checking the information of its holder (plate number, name and mobile phone, etc). The 'SPSPC' system will send an SMS to the tag holder welcoming him and informing him about how many empty slots are available in this specific area (see Figure 6).



Figure 6: Authorized car parked and its related welcoming SMS sample

Scenario 2: authorized person with expired card

During the recognition of the ‘SPSPC’ tag, the system will check in the database if the expiry date of the tag was not reached if it is the case, the system

will send an SMS alerting the tag holder that he has 15 days to renew his tag otherwise he will be considered unauthorized to park and be reported to the parking agents through SMS (see Figure 7).



Figure 7: Authorized car parked with expired tag and its related warning SMS sample

Scenario 3: Unauthorized person without a ‘SPSPC’ RFID tag

If the car parked in this slot is not equipped with a ‘SPSPC’ tag so the system is normally not able to detect it. Consequently, we introduced a step tag which will be fixed in the ground. The system will check the strength of the signal of the step tag using the variable Return Signal Strength Indication (RSSI).

If this variable is weaker than the normal so this means that there is an obstacle that affected it (car parked in the parking slot) and the system will send an alerting SMS message to the agent controlling in that specific area at that specific time informing him that a car without permission is parked so he can move and give a fine to this car owner.



Figure 8: Unauthorized car parked and its related alerting SMS sent to the agent

8. The ‘SPSPC’ System Interfaces

We choose to illustrate some of the ‘SPSPC’ interfaces to show the user-friendliness of our system. In Figure 9, we are presenting the form dedicated for inserting the data related to a new tag holder before providing him with it.

The admin can type the data related to each new tag holder such as name, date of birth, plate number and mobile number. He can search, edit the data, and also delete users.

The screenshot shows a software interface titled "SpecialNeed_frm" with buttons for "Add Person", "Edit Person", and "Delete Person". It features a "MAWIN RFID" logo and a wheelchair icon. The form contains several input fields: Person ID (E200 9020 1403 0195 1160 A1AD), Person Name (Khalid Ahmed Abdulla), BirthDate (6/13/2012), Issu Date (6/13/2012), Expiry Date (6/13/2013), Plate Num (4511), Plate Code (A), and Mobile Num (055778869). Below these fields is a table with columns: Pers..., Issue D..., Empry..., Person Name, Birthdate, Plate N..., Plate C..., and Mobile ...

Pers...	Issue D...	Empry...	Person Name	Birthdate	Plate N...	Plate C...	Mobile ...
E200 9...	2012-06...	2013-06...	Khalid Ahmed A...	2012-06...	4511	A	055778...
E200 9...	2012-06...	2012-06...	Mansoor Moham...	1973-06...	7890	B	050778...
1234 1...	2012-06...	2013-06...	Mansoor Ahmed	1995-06...	6580	E	050452...
E200 9...	2012-06...	2013-06...	Sami Ahmed	2012-06...	70	E	050778...

Buttons for "Save" and "Cancel" are located at the bottom of the form.

Figure 9: Data entry form for ‘SPSPC’ tag holders

The Figure 10 represents the main form of ‘SPSPC’ application. This interface is a kind of dashboard grouping all the critical information of the ‘SPSPC’ system. 1) The status of the connection to the RFID reader. 2) The data of the tag holder tracked by the

system that is extracted from the database. 3) The information of the parking agent who is working in the current slot of time to send him SMS in case of parking violation. 4) The status of the serial port connection to the SMS module and its availability to send SMSs.

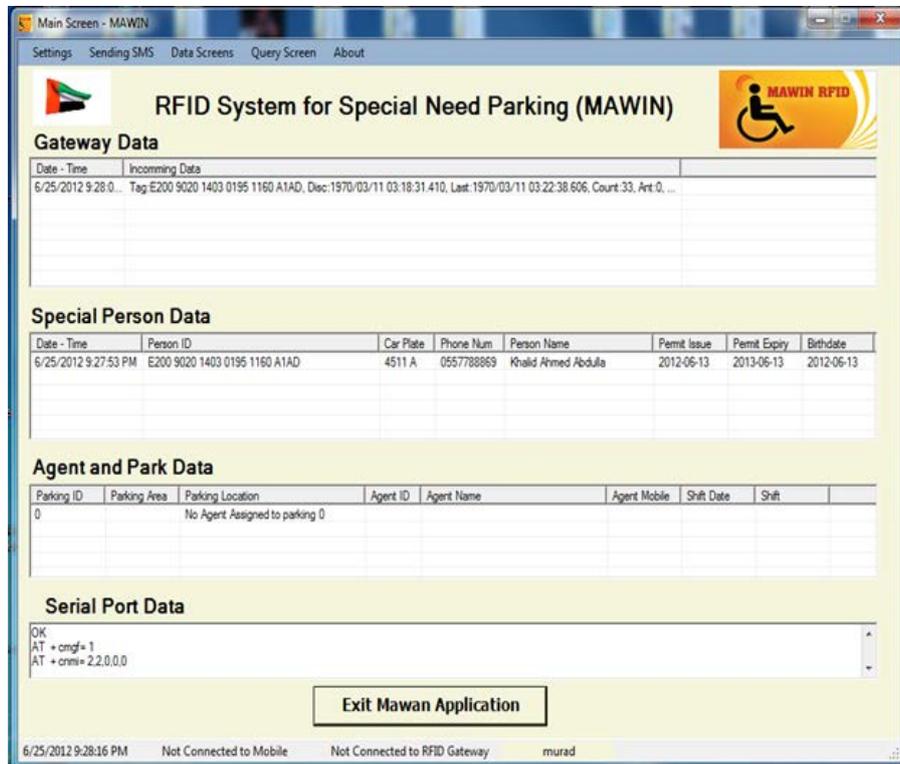


Figure 10: the ‘SPSPC’ system main form

9. Results and findings

We presented in this paper the implementation of an RFID-based solution for automating the process of monitoring physically challenged parking slots. The ‘SPSPC’ system is able to track not only cars equipped with tags and verify their validity but also cars without tags by checking the strength of the signal emanating from the step tag. SMS are sent according to each scenario to the correspondent person either a welcoming or a warning message to physically challenged or to the parking agent to give a fine to the unauthorized parked car. This work is currently under patent and we are working on the adoption of this system by governmental authority as well as shopping malls. Even though the ‘SPSPC’ RFID system is currently used in a small scale, we are currently gathering some feedbacks and needs from users of this system.

In the perspective to improve it and make it useful and useable in large scale, we structured the gathered feedbacks in the form of recommendations in the following:

- In case of unavailability of parking slots, redirect the persons to the nearest valet parking desk via SMS in order to park freely using their RFID tag or card.
- Orient physically challenged to the nearest entrance equipped with special needs facilities
- Sending SMS informing the locations of the dedicated lifts for physically challenged to be used in order to move inside the mall/building
- Sending SMS for products / events/ announcements related to physically challenged (exhibitions, conferences, shops, etc.)
- Provide on emergency cases the possibility for querying the system via SMS and read medical

data related to physically challenged (blood group, if they are under a special treatment or drug, contact number of persons to refer to in emergency cases, etc.)

- Maintaining a history of all created data and analyzing it to :
 - Track people who frequently misuse special needs person's parking slots and act accordingly.
 - Calculate the occupancy rate of special needs parking slots.
 - Generate statistics that can lead to the provision of additional parking slots in some specific areas.

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