

## Study and design of an electronic access control to “Al Raudah al Sharifah” via smart card in order to manage the crowds

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**Abstract:** This paper deals with the research of organizing and managing crowds during the visit of the Holy Raudah in the Prophet’s Mosque and. The everyday noticed fact is the visitors crowding in an attempt to enter the honourable place to pray in it.

In this work, we propose the idea of designing and creating an electronic access control to enter the Holy Raudah via using a smart card. These cards are enabled to visitors with certain studied policies. They will be programmed with well-thought-out settings that contribute to organize the crowds during the entry through electronic portals. The implementation of the proposed idea is based on RFID technology and ARDUINO controller, used together to make an explanatory prototype. This solution, if applied and adopted, will offer to visitors and in particular women visitors, sufficient time to perform their rituals in the best way without harm or discomfort.

**Keywords:** The Prophet's Mosque, the Holy Raudah, visitors crowded, smart card, electronic access, RFID technology, Arduino.

## دراسة وتصميم تحكم إلكتروني في الدخول إلى "الروضة الشريفة" باستخدام البطاقة الذكية من أجل إدارة الحشود

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الملخص: تندرج هذه الورقة في إطار بحث تنظيم وإدارة الحشود أثناء زيارة الروضة الشريفة في المسجد النبوي. والحقيقة الملحوظة كل يوم هي ازدحام الزائرين في محاولة لدخول الروضة المشرفة للصلاة فيها. في هذا العمل نطرح فكرة دراسة وتصميم تحكم إلكتروني في الدخول إلى الروضة المشرفة باستخدام البطاقة الذكية. يتم تمكين للزائر من هذه البطاقات في شروط معينة وتتم برمجتها بإعدادات مدروسة جيداً تساهم في تنظيم دخول الحشود عبر بوابات إلكترونية. يعتمد تنفيذ الفكرة المقترحة على تقنية RFID وبطاقة الازدوينو لعمل نموذج أولي توضيحي. في حين تم اعتماد وتطبيق هذا المقترح، سيوفر للزوار وخاصة الزائرات الوقت الكافي لأداء طقوسهم بأفضل طريقة دون أذى أو إزعاج.

## 1. Introduction

Residents of Medina and its visitors, including pilgrims, Umrah performers and others, have been flocking to pray in the Holy Raudah and to greet the prophet Mohamed ﷺ in the Prophetic room. In fact, Muslims are attached to this pure spot because of its holiness, as our Master, the Messenger of God, said about it "What is between my house and my pulpit is a garden of Paradise" [1]. Thus, how can a Muslim having the opportunity to visit a garden from Paradise while he is on earth and do not? Crowding has led to many expansions in the Prophet's Mosque. Last statistics about the mosque's capacity demonstrate that it is about 707.000 prayers and it can reach more than one million prayers during rush hours [2].

However, throughout the years and in all seasons, the Holy Raudah witness dense crowds usually leading to scramble that may sometimes causes injuries or fainting, especially among women.

In this study we especially mention women, as the visit allocated to them is limited in time and space. From our personal experience when entering the Holy Raudah, we can be certain that entering and praying there has become closer to suffering than it is to the pleasure of worship due to crowding and jostling among the visitors.

Unfortunately, every new expansion of the architecture of the Prophet's Mosque does not take into account rising women chances in visiting and praying in the Holy Raudah or even trying to organize the current crowds in a way that enables them to enter, worship and leave safely.

Therefore, in this paper, we will propose an idea that enables the management and organization of crowds of visitors without the need to change the times or the routes allocated for visitors.

The idea is to study and create a smart entry card that the visitor uses to enter the Holy Raudah through electronic access, and it is the only outlet that does not open except using a valid card and closes whenever the number of visitors reaches a specific number.

In what follows, a study of the current conditions in the Holy Raudah and the implications of crowd density is done. Then, some studies and research in finding solutions to the issue of crowd management are presented. In a fourth part, we explain the study of using a smart card and electronic doors from its various aspects. This includes the conditions, the way and the effect of their use on crowd management and organization. An explanation of the technical aspect concerned with programming and designing the card, based on the RFID technology and Arduino, comes in a fifth section. The sixth part discusses some points and analyses some statistics. The work concludes with a conclusion and recommendations that may represent future research topics.

## 2. Problem statement

The Prophet's Mosque in Medina, in the west of the Kingdom of Saudi Arabia, and it is the mosque of our master Muhammad, the Messenger of God ﷺ, and it is the second holiest house of

worship after the Grand Mosque in Makkah Al-Mukarramah and one of the three mosques to which travelers are drawn according to what said our prophet: "You only travel to three mosques, the Grand Mosque and my mosque and the Al-Aqsa Mosque", he also said "Whoever came to me as a visitor, nothing removed except for my visit, I really had to be his intercessor on the Day of Resurrection" <sup>[1]</sup>. The Coran and the Sunnah contain many facts and evidence of the greatness of this place and its sanctity, which explains the crowding of Muslims to enter the Holy Raudah and visit the Prophet's room.

The mosque has witnessed, over the years, many expansions and architectural developments, the largest one was in the Saudi era, in an attempt to increase the capacity of absorption and organizing crowds <sup>[2]</sup>. It has also taken many organizational measures to facilitate the process of entering the Holy Raudah, such as setting specific times for the visit and specific doors and paths that enable visitors to enter. Based on the guide of visitors to the Prophet's Mosque, the dates for women to enter the Holy Raudah are as follows: The first period: from the time of sun rise to before the noon prayer. The second period: from after the noon prayer until the close of the afternoon prayer. The third period: from after the evening prayer until the second hour, and men are allowed to enter all the day.

For the entrance doors to the Holy Raudah, Bab al-Salam and Bab al-Baqi 'areas are designated for men, while the masses of women enter from the gate of our master Othman, may God be pleased with him <sup>[3]</sup>. Perhaps we do not exaggerate if we say that the female crowd is starting to enter, causing the sweeping torrent to start, causing great suffering for Muslim women while trying to enter, as shown in figure 1. This crowd may lead to depriving many of visitors from the pleasure of feeling the greatness of the place and performing the worship as it should be with tranquility. In fact, tranquility is almost lost <sup>[3]</sup>.



Figure (1) Crowds of women in the Holy Raudah in the Prophet's Mosque <sup>[4]</sup>.

### 3. Previous studies

Regarding this problem, there have always been demands to create mechanisms that organize the visit of women to the Holy Raudah, taking into account the space and time allocated to them. The problem was previously presented in a deliberation of the "Shura Council", in which a number of specialists in the field of Islamic Architectural Engineering demanded the necessity of finding engineering alternatives to

increase the absorptive capacity around the Prophet's room and the Holy Raudah. Dr. Wafaa Mahmoud Taiba, a member of the "Shura Council", confirmed that despite the efforts made to regulate the entry of women to the Holy Raudah, the problem must be dealt with new aspects to obtain a solution, as the current organization does not meet the purpose. Dr. Wafaa mentioned in these aspects the technical solutions <sup>[5]</sup>.

In the same context, the Servant of the Two Holy Mosques Institute for Hajj and Umrah Researchs presented many ideas and proposals that were explained by Dr. Muhammad Idris <sup>[6]</sup>. One of the main proposals was the idea of using the tracks and applying them at non-peak times, for its ease and no need of construction work. The idea is presented in Figure 2.

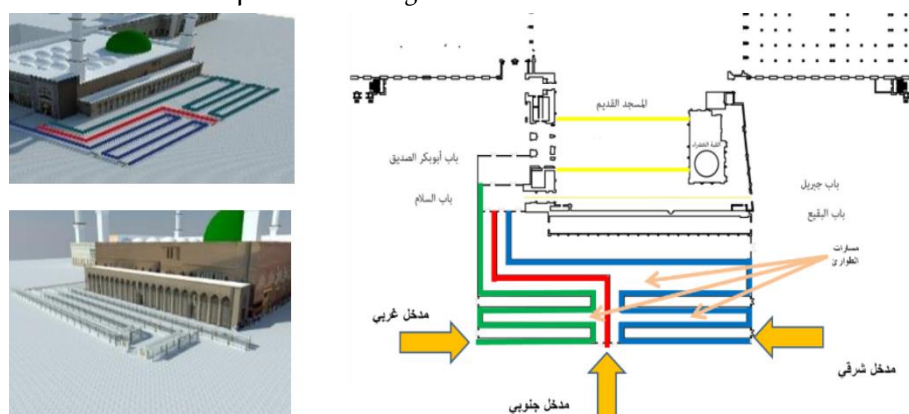


Figure (2) Use of paths and block fragmentation <sup>[6]</sup>.

Several studies, research, and efforts were made to solve the problem of the Raudah's crowd management <sup>[5, 6]</sup>, we have mentioned just some of them. But all these studies dealt with organizing outside the borders of the Holy Raudah without the ability to control crowding inside it and near the place of the Holy Prophet, where the number is double the capacity of the place's absorption. All of this prevents visitors from praying and even supplicating in reverence, especially on the side of women, because of the lack of time and space for their visit.

#### 4. Proposed system's working

We propose in this work an idea that is fitting with technological developments and with the age of information and artificial intelligence. The idea is to design an electronic access control to "Al Rauda al sharifa" based on a smart card.

The proposed idea does not contradict and does not cancel the great effort made by the General Presidency of the Two Holy Mosques, but it contributes to shortening the effort and enables visitors to pray in reverence and reassurance within the Holy Raudah. This proposal will reduce the number of people present inside to the capacity limit of the place. So that, overcrowding is prevented and visitors get more enough time to pray before the doors open and another group enters.

#### 4.1. Electronic gates

The idea of electronic doors can be summarized in the following points:

- Electronic gates are only for the entrances to the Holy Raudah, and their number is determined according to the geometry of the place.
- The gates are equipped with a card reader and they open only when a valid card is passed, and all gates share a digital counter that calculates the number of cards that have been passed so that the gates are closed as soon as the number inside the Raudah reaches 200 visitors, considering that it is the approximate number of the place's capacity.
- The doors remain closed for a specific period of time, which may be from 10 to 15 minutes, which enables the group inside the Raudah to pray and supplicate without jostling, crowding or fear of injuries.
- Providing the Raudah with lights of changing colors from the exit and entry points that guide the regiments when the gates are opened and when it is time to exit. For example, a green signal may be lit to inform those waiting outside the Raudah to prepare to enter. At the same time a red signal will light up inside to inform those inside of the need to go out and the time for their visit ends to allow others to enter.
- It is preferable to have men and women assistants at the gates in case of emergency, such as helping to use the card and preventing non-card holders from entering by force.

It is obvious that some of the aforementioned points may suffer from obstacles or limitations in implementation. This issue can be discussed in relation with actual situation and architecture of the place.

#### 4.2. Smart card usage and distribution policies

In order to guarantee that the smart card will be useful in organizing crowds and make a change in the degree of suffering to enter and stay for a while in quietness inside the Holy raudah, a set of settings can be taken into account while programming and distributing the card.

- The card does not contain personal information, and the visitor can get it from specific distribution points (it can even be a slot machine) at an affordable price. This price or a part of it is refundable by the visitor in case he returns the card in proper condition to any distribution point. This latter proposal will reinforce two aspects, the first is to emphasize that the purpose of the card is not profitable and to avoid criticism in this regard, and the second is to reduce the number of cards and thus reduce their cost.
- The card enables the visitor to enter with it a number of times - twice or three - provided that the time between two consecutive visits is not less than 24 hours, which means that whoever uses a card to enter in the morning, with this card will not be able to enter in the evening.

- The recovered cards must be re-modified - meaning they are returned valid for the benefit of other people.
- The beneficiary of the card has the right to re-amend it for a fee if he has exhausted his balance from the entries to the Holy Raudah without acquiring another card.
- A special application for the smart card can be created on smart phones. That application clarifies the conditions for using the card, displays the supplications and etiquette for the user in the Holy Raudah, and alerts him that it is time to be out, if he is inside.

## 5. Electronic components and control flow

Firstly, to choose or design the gates, there are many manufacturers of electronic doors with various designs and settings. To implement and succeed the idea, we need a gate that does not take a relatively large space because we already suffer from the problem of small space. Besides, the gate must be designed for high traffic volume where it enables the entering of a large number in a short time, for example, at a rate of 50 people per minute. If we assume that there are two gates, 200 people will be entered within two minutes, and then the doors will be closed for a period of 13 minutes, for example, and then they will be opened to a second group. That is, if we adopt these data, 800 people will be able to enter every hour to pray in the Holy Raudah without crowding. 6400 visitors have the possibility to enter quietly during 8 hours.

The process of counting the persons entering the Holy Raudah requires a central access control device consisting of a central control panel to which all electronic locks and card readers can be connected. These panels can accommodate from 2 to 4 electronic doors depending on the type and the manufacturer of these panels.

Among the requirements of the automated portal, it should be designed for smooth and silent operation and consumes little energy to reduce the financial cost of the proposal. Figure 3 shows some models of electronic doors. There are many other shapes that are manufactured according to the request of the concerned authority.



**Figure (3) Electronic gate models.**

Secondly, for the card, the technique (RFID: Radio Frequency Identification) will be used in this prototype. This technique means identification using radio waves, which is one of the most prominent techniques of near-range communication<sup>[7,8,10]</sup>. It is constituted with 3 main components:

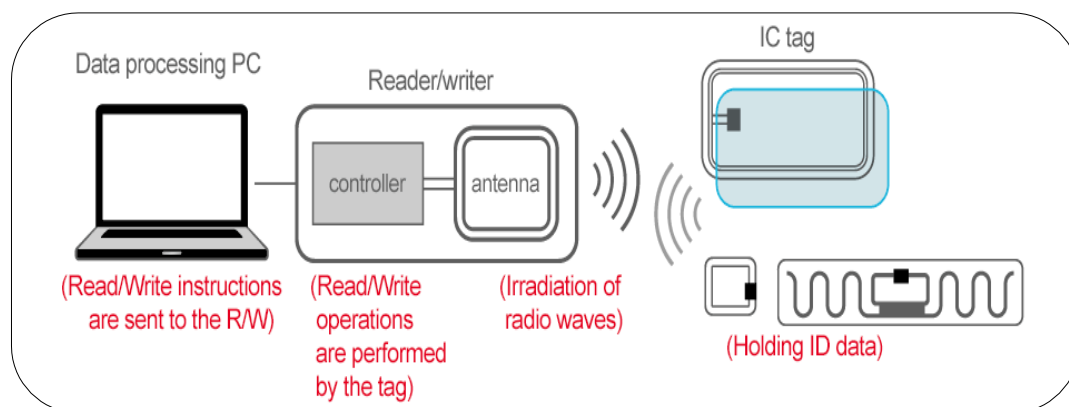
1. The card that contains the transmitter and information.
2. Reading and transmitting device.
3. Computer programs and databases.

The RFID chips are in the form of cards that can be installed on things, and these very small chips contain an antenna to receive the waves, which is in the form of a thin wire wrapped inside the card. The role of this antenna is to emit radio signals to activate the tag and to read and write data to it <sup>[10]</sup>.

The radio waves are emitted from the reader 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 <sup>[10]</sup>.

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.

RFID tag consists of a microchip attached to the radio antenna. That chip can store as much as 2 kilobytes of data <sup>[8]</sup>. Figure 4 illustrates the principle of RFID working and communication.



**Figure (4) Principle of RFID working and communication.**

In order to design and test the algorithm of the proposed idea, the prototype for the access control system is created based on RFID and Arduino UNO microcontroller.

Many other controllers can be used, we choose Arduino because it is an open source physical computing platform based on a simple input/output (I/O) board and a development environment implementing the Processing language. It can be used to develop standalone interactive objects or can be connected to software on your computer <sup>[9]</sup>.

Both components together, RFID and Arduino, were used in similar way but for different applications and aims <sup>[10, 11, 12]</sup>.

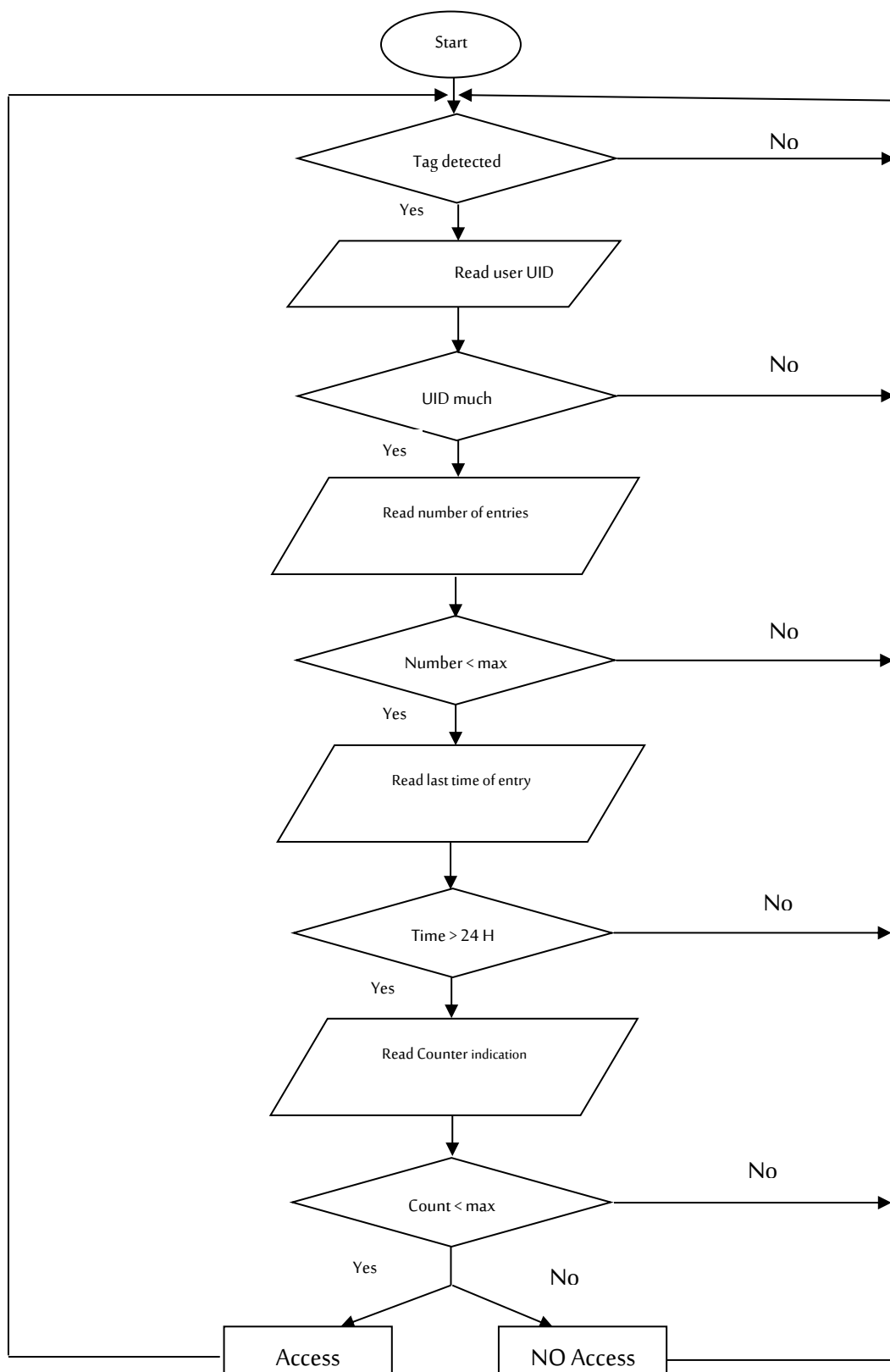


Figure (5) The control flow for the proposed automatic access system.



As shown by the control flow diagram in figure 5, in our system, when a card holder places the RFID tag close to the entry gate, where is installed the RFID reader, the system checks some conditions before allowing visitor to enter.

- The first test is about the detection of the tag.
- The second condition is the acceptance of the user unique identifier UID <sup>[11]</sup>.
- The third condition is the validity of the card in relation with the number of entries and the time of the last entry.
- Finally, the user will get access if the counter does not indicate that the maximum number of visitors is reached yet.

If any of these conditions is not satisfied, the access will be denied for user (Figure 5).

The electronic circuit of the proposed access control's prototype is showed by figure 6. The LCD display is used to display the state of the access either accepted or denied and if denied, for what reason. The servo motor is the actuator in this system, opening or closing the gate. The green and the red LEDs are used to inform visitors, respectively, about the time of entry and time of exit.

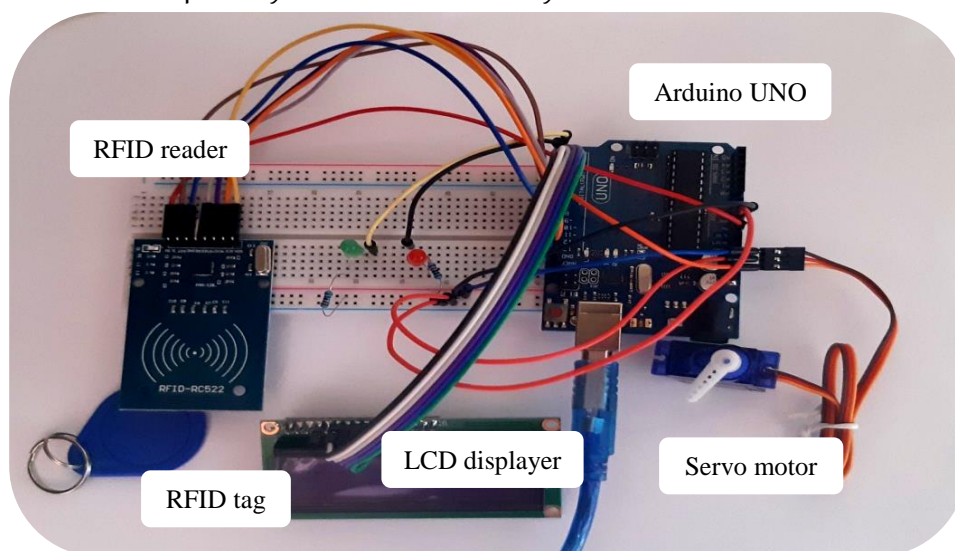
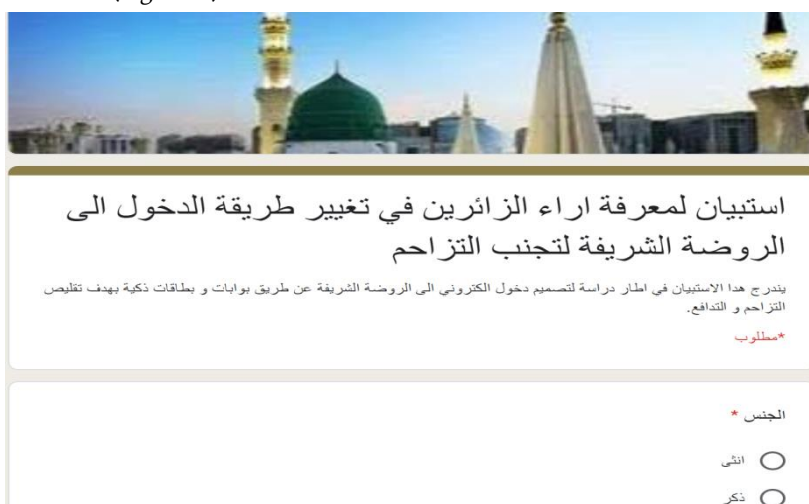


Figure (6) Electronic Access Control system prototype using Arduino, RFID and counter.

## 6. Discussion

The prototype of the proposed system shows expected results in relation with the given description. However, it is not sure what can be the results in relation with the architecture of the Mosque and the Holy Raudah. In fact, the idea seemed to be not implementable or perhaps difficult to comprehend. I had many questions about whether the idea had been proposed or taken up before but refuted for certain reasons. But after searching for an answer to these questions, We realized the necessity of presenting the idea and discussing it with the specialists that are in charge of the affairs of the Prophet's Mosque and those with experience in the specialty of modern technologies, in one side.

In the other side, the visitors' opinions about the idea of paid cards and electronic access seem to be primordial. We illustrated them via a questionnaire. This latter, consisting of eight questions, was published on social media (Figure 7).



استبيان لمعرفة آراء الزائرين في تغيير طريقة الدخول الى  
الروضة الشريفة لتجنب التزاحم

يندرج هذا الاستبيان في إطار دراسة لتصميم دخول الكتروني الى الروضة الشريفة عن طريق بوابات و بطاقات ذكية بهدف تخليص  
التزاحم و التدافع.

\*مطلوب

الجنس \*

انثى

ذكر

**Figure (7) A questionnaire to find out the opinions of the visitors about the proposed electronic access.**

The results of the questionnaire, as illustrated in figure 8, were:

- The majority of responders were women with about 81%.
- About 77% confirmed that the overcrowding is intense in the Holy Raudah.
- Asking about the negative influence of the crowding on the prayer and worship, about 90% of answers agree.
- Asking if the crowding can affect badly the safety of visitors, about 77% of answers was yes.
- Almost 94% of responders expect that using electronic entry through gates and smart cards can reduce crowding. However, just 85% of them accept to buy a smart card to enter the Holy Raudah. More than 10% of people refuse paying money to enter.
- About the feasibility of the proposed idea, 60% of responders guess it is possible to apply it, however, almost 35% of them, answer that they don't know and it so obvious since the implementation is a technical aspect.

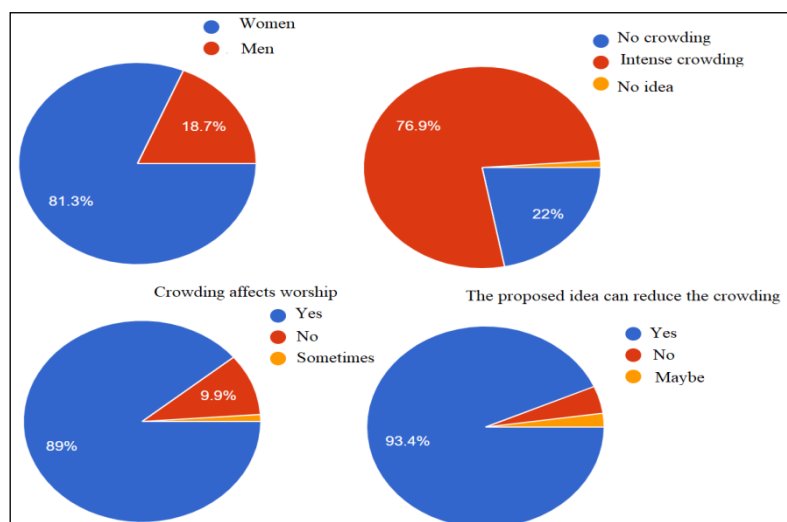


Figure (8) Extract from the statistics results of the questionnaire.

These statistics confirm, first of all, that the problem of crowding is essentially proposed with women. Secondly, answers agree that the overcrowding has, generally, bad effects on safety and worship. That means the problem is there and people think that the proposed idea can, strongly, be the solution.

## 7. Conclusion

The work in this paper tried to find effective solution towards the problem of crowds in the Holy Raudah. The proposed solution dealt with the design of an electronic access control based on RFID technology and Arduino controller. Visitors are supposed to use a smart card to enter safely to the Raudah and stay enough time to pray without crowd.

The work cannot be achieved and applied on real world without studying the whole architecture and infrastructure of the Prophet's mosque, which will be done in future work.

## Recommendations

Before applying this idea in "Al Raudah Al sharifa", some points must be discussed and taken into consideration:

- We have to ask the opinion of the legal jurisprudential committee about the permissibility of implementing the idea.
- We should be well informed about the whole infrastructure and architecture of the Prophetic mosque. This step is essential to generalize the idea.
- Once the idea is applied, visitors must be made aware of respecting the electronic access policies and of respecting the exit time from the Holy Raudah since there is no deterrent proposed yet.

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