QR code based access control system for hotels

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Abstract
The actual situation facing mankind due to the new Coronavirus is pushing researchers to develop new technologies that involve physical distancing for people, in many domains. But life goes on, and although some activities can be carried out online, there are some domains that require human presence. For example, analysis of the environment, evaluating exposure to different toxicants to different ecosystems are some of the activities in the environment sector that need to be carried out involving human presence. This is why this paper will propose a system that limits human contact during hotel stays for scientists, researchers, or tourists.

Keywords: QR codes, access control, NFC.

1. INTRODUCTION

Covid 19 crisis is a matter of adaptation and survival for tourism service providers and for all activities that need human contact. People are now very cautious when choosing places where they can spend their vacations or where they can accommodate for different activities, research, or study. New kinds of services and safe facilities are demanded because people need to feel safe. That is the reason why accommodation service providers have to adapt to current needs and to improve their services if they want to stay on the market. Another important issue for hoteliers is the safety of their employees. They are contacting daily lots of people and measures have to be taken in order to reduce the risk of infection.

But every reorganization, every new idea of reducing human contact involves costs. These costs are clearly affecting the hotel business and this aspect has to be taken into account for sustainability reasons. This is the reason why service providers are very keen on knowing what are the most efficient and profitable investments that they should make in order to keep their business running in the safest conditions for both tourists and employees.

The first activity that implies human contact when arriving at a hotel is registration and room access. Different techniques have been developed in the past for access control. One of them was the access based on a PIN (personal identification number). This PIN was typed using a touchpad. If we think now about this system, the risk of infection is big due to the need of touching the keypads. Also, PINs can be forgotten or can get into unauthorized hands.

Other solutions were the use of contactless RFID (radio frequency identification) systems [1], [2]. The RFID tags used in this kind of technology are used for storing and remotely accessing data. Radio waves are used for data transmission from tags to readers that are connected to a host computer [10], [11].

Solutions involving biometric authentication were also proposed for facilities access. This idea involves creating authentication keys by using one or more of the unique physical parts of guests.

Ideas like face detection, fingerprints, voice recognition were proposed. These kinds of biometric systems are rarely used due to their implementation cost and complexity [3], [4], [17].

The use of robots for replacing front desk operators is also one of the recently implemented innovative solutions. But, for accommodation service providers is not such a suitable solution, because of costs and the possibility of servicing a large number of people once [5], [6], [7].

Using NFC (Near Field Communication) systems is another innovative developed idea. Taking into account the recent evolution of smartphones and applications that changed the lifestyle of people due to the storage and computing performances, these systems tend to integrate into the current use of hoteliers. Initial solutions required that processing and storage of information to be done on the smartphone [8], [14], but there was the risk of phone stealing and hacking. That is why the security method had to be enhanced by using an additional digital secure key. In [9] the authors propose two solutions for additional authentication methods: a NFC-enabled smartphone with a digital secure key and a NFC combined with an encrypted steganography graphical password.

This paper brings a first step for implementing an HMS (Hotel Management System) that can be used for large or small accommodation facilities and that can help both tenants and employees for having a secure stay. The proposed system is based on Raspberry Pi® platforms integrated into an access control server.

The rest of the paper is organized as follows. Section II discusses the architecture of the proposed solution. Section III presents the hardware used for implementing the system and Section IV describes parts of the software developed for servicing the HMS. The last section will summarize the main contributions of the paper.

2. PROPOSED SOLUTION FOR HMS

QR (Quick Response) codes are two-dimensional codes that have the advantage of being much faster read compared to classic barcodes and also can uptake large data amounts [12], [13], [15]. Firstly used in the automobile manufacturing industry for identification of parts of a vehicle, the QR codes are now present in applications like supply chain, marketing, restaurants, etc.

A QR code's main benefit is that it offers a reliable, inexpensive, and simple way to transmit information in a "push" format to different recipients. Another benefit is the current open source libraries which can be used to produce QR codes from different data sources. The quantity of data transmitted depends on the version of the QR code generator, but the messages will be decrypted at reception by the programs or applications that are up to date [16], [18]. This facility helps the receiving application to parse the data received from the tag and then use this information according to how the programmer chooses. Despite the different standards used in each revision of codes regarding redundancy, availability, and data integrity, once the QR code is read, the information can be used in any operating system that supports the open source libraries for encoding/decoding. These codes don't give users the possibility of manually entering data, thus another advantage appears, because in this way data accuracy is ensured.

Based on QR code advantages, the HMS prototype for access control has been developed. Figure 1 shows the main components of the system. The idea is to use QR codes in order to give access to tourists in an accommodation facility. The system has three big components. A central server that controls all access doors, a black box for each room which is used for receiving information about access and other sensors in the room, and readers for each door.

The communication between the server and the black boxes from each room is done through TCP/IP protocol. The server is responsible for data centralization, QR code modifications, booking procedures, external commands for main program management but also ensures automatic firmware updates. Also on this server are stored video feeds from cameras that are also used as a CCTV (Closed Circuit Television) system. Other proposed capabilities of the system are those regarding face recognition access, burglary monitoring, or fire detection.

The black box used for each room is composed of a Raspberry Pi® processor with an extension GPIO (General Purpose Input/Output) module which is able to connect different devices in the room.

Each door in the accommodation facility will be provided with a subsystem containing readers and displays. There will be two possible ways of accessing the room. One way is using QR code generated when booking is made and, in the case of malfunctions, RFID tags can be used. The displays help tourists with the steps needed to access the room and also give information about the date when the room needs to be freed. Also, the displays will be used for confirmation messages.
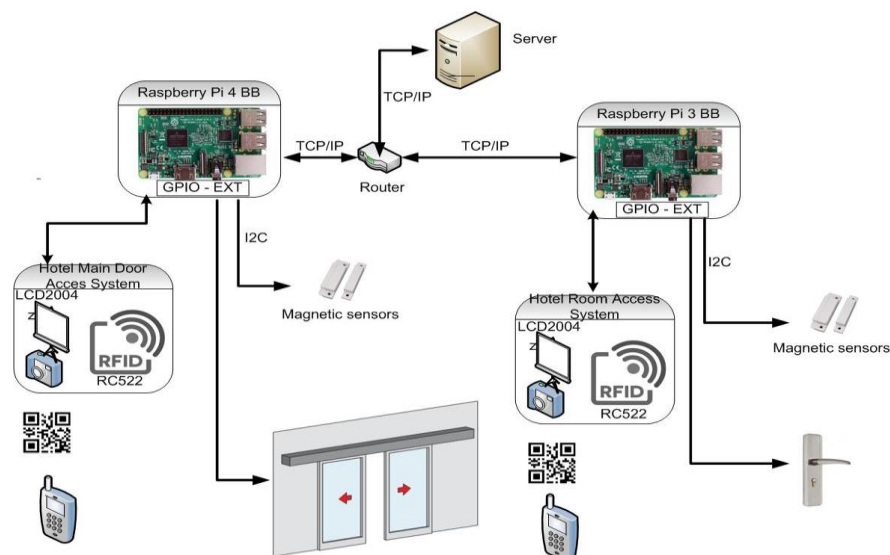

Fig. 1. Architecture of the proposed HMS

3. HARDWARE DESCRIPTION AND IMPLEMENTATION

Following the architecture proposed in figure 1, a prototype system has been developed. The system from one room can be easily multiplied to other rooms, the only limitation being the communication to the server.

Each subsystem developed for a room has integrated a Microsoft HD 3000 camera which has a video resolution of 1280 x 720 pixels and USB 2.0 communication to the Raspberry Pi board. The camera is used for QR code reading and sends the information to the processor, for decoding.

Fig. 2. HD Camera and LCD2004 for room access

Along with the camera, an LCD2004 display is used for giving the user information about the next steps that need to be done for room access or confirmation messages after actions are taken by the

user. The LCD2004 is a 76 mm x 26 mm digital display powered at 5V from the black box in each room. This LCD2004 can display 20 characters on 4 lines and has an interface input data of 4 or 8 bits.

In case of problems with the QR code or with the camera, the access can be ensured by a backup access system based on RFID tags. The RC522 RFID reader used for this option is also mounted near the display. This reader is working at 13.56 MHz and supports different cards: S50, S70, UltraLight, Pro, and Desfire. It supports three communication protocols: RS232 up to 1228.8 kbauds, SPI (Serial Peripheral Interface) up to 10 Mbit/s, or I2C up to 400 kbaud in Fast Mode and up to 3400 kbaud in High-Speed Mode.

Figure 2 shows a prototype access subsystem that can be mounted outside a hotel room. This subsystem is connected to the prototype black box described in figure 3. Here there is the central unit represented by a Raspberry Pi 3 platform. This platform is based on a Broadcom BCM2837B0 processor, with Cortex A53 64 bit architecture, working at 1.4 GHz. Some of the platform's features are: 1 GB SDRAM, wireless connectivity at 2.4 and 5 GHz, Ethernet Gigabit connectivity at maximum 300Mbps, 4 USB 2.0 ports, Bluetooth 4.2. For video processing, the platform has H.264 encoding and H.264 and MPEG.4 decoding at 1080p and 30 frames per second. In order to extend the capabilities of the platform, a GPIO expansion board has been used.

The system is powered from a 2A 220V/12V power source and has a battery charging module in case of power failure in the building. For supplying the locks and sensors OMRON relays are used. The system shown in figures 2 and 3 is a prototype and now is being enhanced in order to be tested.
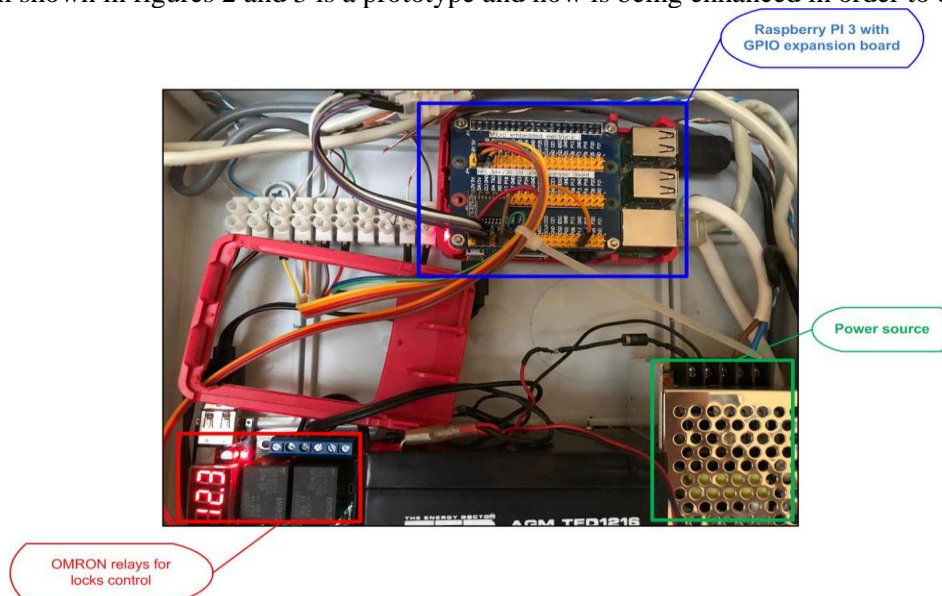

Fig. 3. Prototype system BB for room access

4. SOFTWARE IMPLEMENTATION

The software for the HMS is based on Phyton language, customized for Linux operating system. It allows settings of cards, generation and transmission of QR codes for each accommodation to customers, room status monitoring, employee and customer access monitoring for any form of access such as QR Code, RFID (Radio Frequency Identification) card, face-recognition, secure opening of remote doors, firmware updates for each black box, reboot actions, etc.

There are two big steps when talking about accommodating to a hotel room. The first one is the booking and registration, and the second the actual access to the hotel facilities and in the room. In order to reduce human contact as much as possible, for the first step, booking and registration can be done by the client, by accessing a specific site at home, as shown in figure 4. The client needs to provide some information and a picture should be taken, in order to have enough data for generating the unique QR code. After the online payment is confirmed, the tourist will receive his QR code with which he will be able to open the main entrance and also the room that he has booked.

Another part that is managed by the implemented software is access in the room / main entrance. The tourist will use his unique QR code printed or on his smartphone. The camera will read the code, will send the information to the server and if everything is ok, the door lock will be opened.
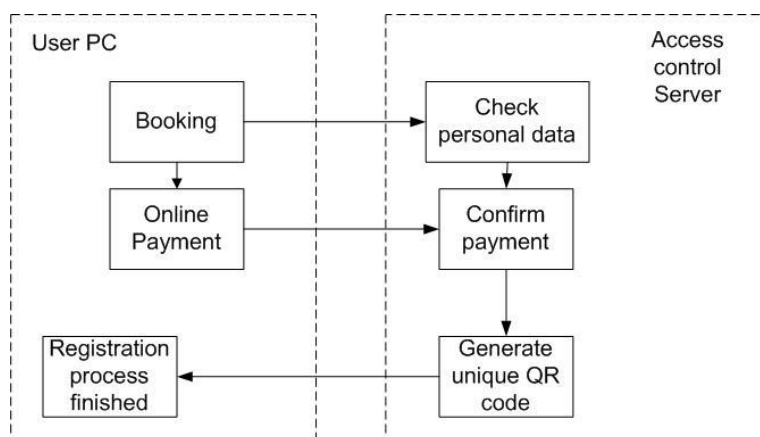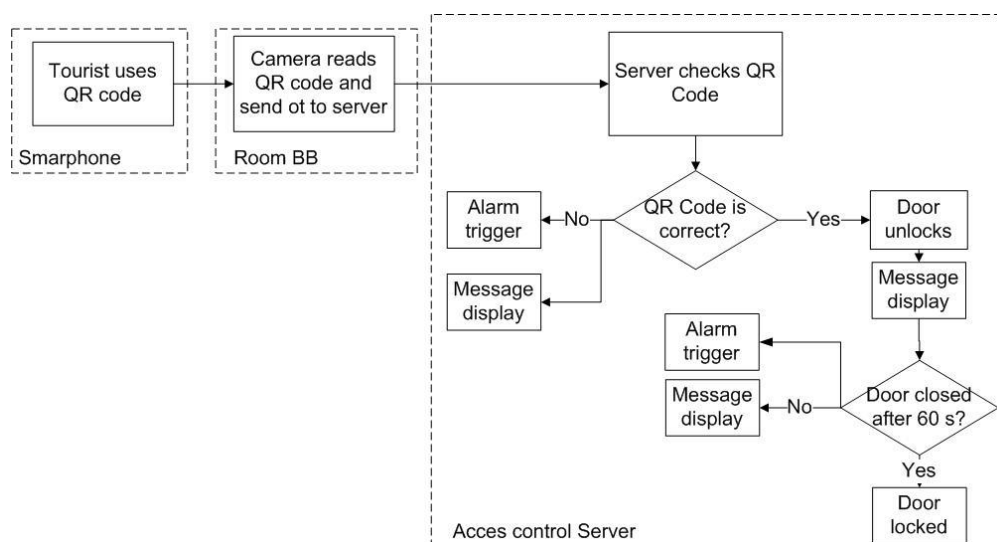

Fig. 4. Booking and QR code generating process

Fig. 5. Access control diagram

The implemented software on the server also manages the period of availability for the QR code, depending on the number of days booked, the video surveillance in the hotel hallways, using the same camera, and access monitoring for employees. The next steps in software implementation could be a face recognition system, burglary monitoring, fire detection, etc.

5. CONCLUSIONS

This paper proposes a combined HMS that can replace the front desk activities of a hotel or different accommodation units. The specially developed system provides self-check-in capabilities using a QR code. The code will be generated when the booking is made. Also, after the check-in, the users can access their rooms using the same unique QR code. The same code will also be used for entering the hotel facilities. This paper also brings an energy-saving solution that is integrated into the HMS. The idea is to limit the waste of energy in the hotel room, but in such a manner that doesn't affect the commodity of the tourist. For security issues, the HMS will be equipped with a CCTV system.

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