SMART DOOR LOCK SYSTEM WITH AUTOMATION AND SECURITY

*Ibshar Ishrat, Wajiha Muzaffar Ali, Sana Ghani, Sadia Sami, Maria Waqas[1], Fakhra Aftab[2]
Dept. of Computer and Information Systems Engineering, NEDUET, Karachi, Pakistan
{*ibshar.ishrat@gmail.com, wajihamuzaffarali@gmail.com, sanaghani94@yahoo.com, sadia_sami@ymail.com}
{[1]mariaw@neduet.edu.pk, [2]fakhraaftab@neduet.edu.pk}

ABSTRACT: *This paper presents the design of Smart Door Lock System with Automation and Security - an implementation of IoT (Internet of Things). The system allows the users to monitor and control their homes using the Android device. This system is designed mainly for home door locks; this design can be customized for different kinds of locks as per the need. It uses Raspberry pi as the main device with Raspbian as the operating system to be installed near the lock. Different sensors have been interfaced to detect door bell and knock. It also notifies if any suspicious person is sensed. The system also keeps track of the door status i.e. opened or closed. It notifies the user of the visitor or the suspicious person detected through the mobile application along with the picture. For notification the system has made use of Google Cloud Messaging service. The user, if intends to, can unlock the door for the known visitor or make an emergency call in case of suspicion. The door would be unlocked after the verification of pin code. One Application would be capable of controlling and monitoring different locks.*

KEYWORDS: IoT, Android Application, Raspberry Pi Server, User Validation.

I. INTRODUCTION

Since decades, the world is moving towards automation which has given rise to the term "Internet of Things" i.e. "*A proposed development of the Internet in which everyday objects have network connectivity, allowing them to send and receive data*" [1]. The advancement in technology with time has led to smart access to everyday objects through Internet solving daily life problems and bringing ease. The paper suggests solution for controlling and monitoring door locks remotely i.e. from anywhere in the world via smart phone application. It uses internet to keep the registered users updated about the visitor at the door. It also senses a suspicious person outside the door. The user can unlock the door simply through an android application or make an emergency call in case of suspicion.

Regarding safe unlock of door, quite a lot of work has been done. One paper proposed a solution to deal with two subsystems i.e. control of home appliances and detection of intrusion from main gate, entrance door, living room windows and roof door. The system was based on Wireless Technology i.e. GSM modem and the users were notified about the appliance status and any intrusion through SMS alert. The studies were at initial level. It is not categorized as an IOT solution [2]. Another solution was proposed in the past which was based on Radio Frequency Identification using RFID tag to access a secure zone. It unlocked the door after authenticating and validating the user. The entry information was stored in the database with time and date. The system comprised of RFID reader which reads the RFID tag information and sends output control signal which controls the door unlocking. The security system was based on an RFID tag and reader. This system can be employed in laboratories and work places [3]. Some other solutions have been introduced which were based on Bluetooth Technology on Android Mobile devices for door lock security. They were short ranged i.e. 10-100 meter solutions with a basic android application [4, 5]. There is a paper which introduced Face Recognition Based on Auto-Switching Magnetic Door Lock System Using Microcontroller. The testing image would be selected by the user and matched with the training image stored in database for user authentication before unlocking the door. The system provided biometric identification. However the images were not captured automatically in the proposal [6]. Some technologists developed visitor

notification system using GSM technology with door unlocking. The system made use of quite a lot of hardware [7]. Another system was proposed which was based on the video technology along with Bluetooth technology on Raspberry Pi for communication between visitor and owner as a security feature**.** The recorded video was stored in cloud [8]. One system proposed an automated door control system employing Wi-Fi as well as GSM technology. However, Atmega8 microcontroller was used with basic android application without any user account and the solution lacked security features [9]. There is another system which provided a solution for locking and unlocking using Wi-Fi technology. A simple prototype of Android Application was provided with steps of creating account, logging in and performing lock/unlock action. No monitoring mechanism has been implemented [10]. Another system was proposed Android based smart door lock system with multi-user feature for a single lock. The solution was implemented using Bluetooth Technology [11].

By critical analysis of these systems, it was found that the solutions based on Bluetooth lacked the features of remote monitoring and control because of the range limitation. Some systems provided either smart access to a single door without monitoring or with lack of security measures. The solution that this paper proposes surmounts these limitations by providing a generic automated solution i.e. a user friendly and extensive android application to control and monitor different door locks from anywhere through one android application. The product can be interfaced with any electronic door lock and one lock can be controlled by multiple owners, hence operating at a broader spectrum utilizing latest technology of Raspberry Pi and getting rid of complex hardware. In the following sections of this paper, the methodology and design of the solution is discussed in detail.

II. METHODOLOGY

A system has been developed that uses the Raspberry pi, sensors and an android application manly. Sensors have been used to detect changes in the physical environment of door. For example, in case of a home door, if the bell is rung, door is knocked or there is suspicious person not triggering any of these activities, the sensors detect and provide an input to the Raspberry pi. The camera is enabled in these scenarios to click images. The notification is then sent to users of visitor/suspicious person along with the image and time

stamp. Using a 4-digit pin code, the user can successfully unlock the door remotely through the android application. The door is unlocked after successful verification of the code in the Raspberry pi.

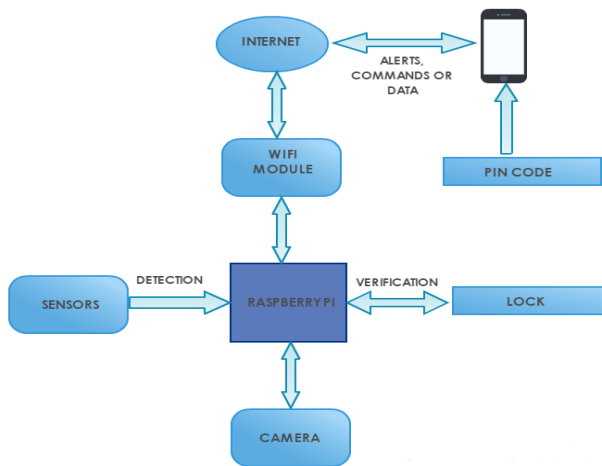Given below is a block diagram that covers the general flow of the system:

Figure 1: The Block Diagram of Proposed System

HARDWARE AND SOFTWARE DEVELOPMENT
A. RASPBERRY PI AS PROCESSING ELEMENT AND SERVER

Raspberry PI model B+ has been employed as the server device. It has high processing capability and can store the data related to the users for authentication. It also stores the images of the visitors.

After the installation of the operating system (Raspbian) in the Raspberry Pi, LAMP was installed to create the web server, so that a database could be maintained and data could be retrieved to/from the server. The GPIO pins of Raspberry Pi were interfaced with the electrical door lock through relay.

B. CAMERA AND DOOR BELL INTERFACING

A prebuilt electronic doorbell and a 5 MP high definition web camera has been used in the proposed solution. It has a transmitter on the pushbutton side and a receiver at the speaker side of the bell. If the user presses the bell the transmitter sends a high signal to the receiver. The signal from the receiver side was supplied as an input to the GPIO pin of the raspberry pi which triggered the camera.

The web camera was interfaced with the raspberry pi. If the doorbell rung or any of the sensors were triggered, the camera was enabled, the clicked picture was then saved in the database and a notification was sent to all the registered users of the device along with the picture and the timestamp.

C. SENSORS INTERFACING

Digital output Shock Sensor has been used to detect someone's knock on the door.

The output pin was connected to the GPIO pin of the raspberry pi. It triggers the camera. The picture was stored in the database and a notification was sent to the registered users along with the picture and the timestamp.

A magnetic reed switch has been used to get the status of the door (opened or closed).

To check the possibility of some suspicious person outside the home, PIR Motion sensor has been used in combination with the obstacle sensor. Both the sensors use infrared rays to detect human movement and an obstacle respectively.

If the PIR sensor detects human movement, the system checks if the bell switch has been pushed or if someone has knocked the door. If the above defined cases do not hold true, then the system checks the reading of the obstacle sensor after a predefined interval of time. If the human movement is detected and obstacle sensor gives a true output after a few seconds, then the camera is enabled. The clicked picture is saved in the database and a notification along with the picture is sent to the users that there might be a suspicious person outside the house. There is an option of emergency call in the application.

A system code was developed in python to handle different scenarios described above.

D. ANDROID APPLICATION AS CLIENT

An extensive and user friendly Android application has been developed to control and monitor the status of door locks. The communication between application and server was achieved by Apache HTTP Client. For data exchange between client and server JSON was employed.

The user has to get registered to the device before using the application, providing personal details. On a single android phone only one user can be registered though one user can login on multiple phones. After successful registration and login, user can insert, delete or edit door locks along with the desired features to be attached with each door (doorbell detection, door knock detection, suspicious person). After login user selects a door and views the activity tab of that door with images of visitors and time of arrival, action tab on which he/she can see all the unlocking actions performed by users of that door, status of different doors (open/closed) and unlock using 4-digit pin code. The pin code is then verified at the device along with the MAC address of client application as an additional security feature. The user guides of how to use application and how to use the device are also available. Moreover a single android device can make only one account on server fortifying the security. Given below are the screenshots of some screens of developed application.

Notification is received on android application whenever any activity is occurred or action is performed. On opening notification application allows user to unlock door after PIN code verification or make emergency call.
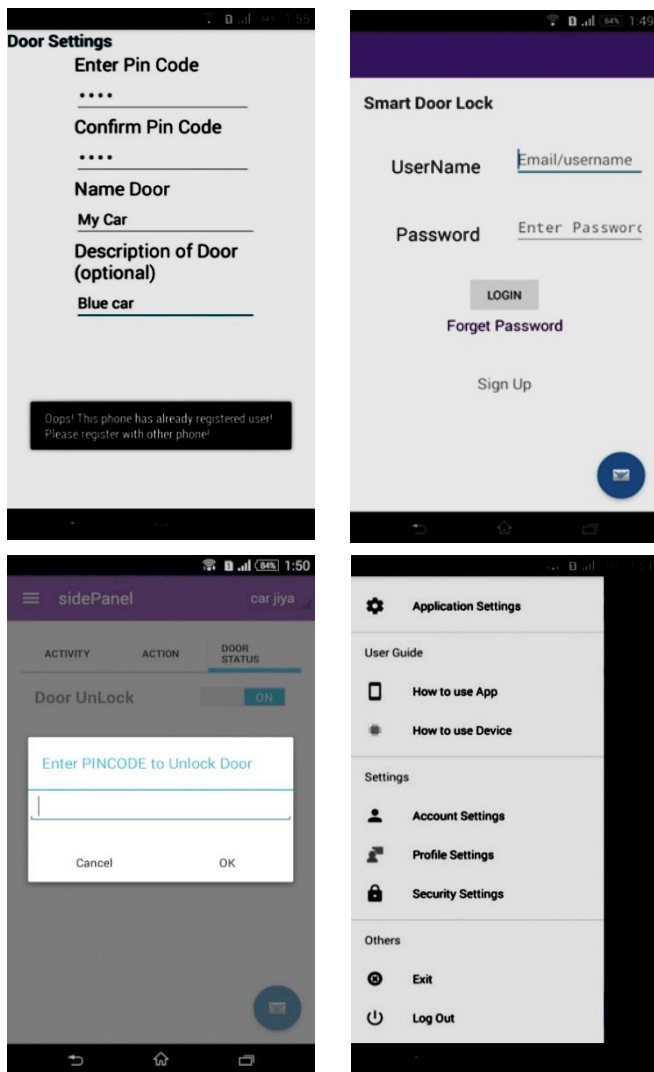
Figure 2: Registration, Login, Door Status and Side Panel

III. DISCUSSION

Given below is the design of product interfaced with home door. The product can be interfaced with any door with customized features (i.e. camera, doorbell, door knock) according to user requirement.
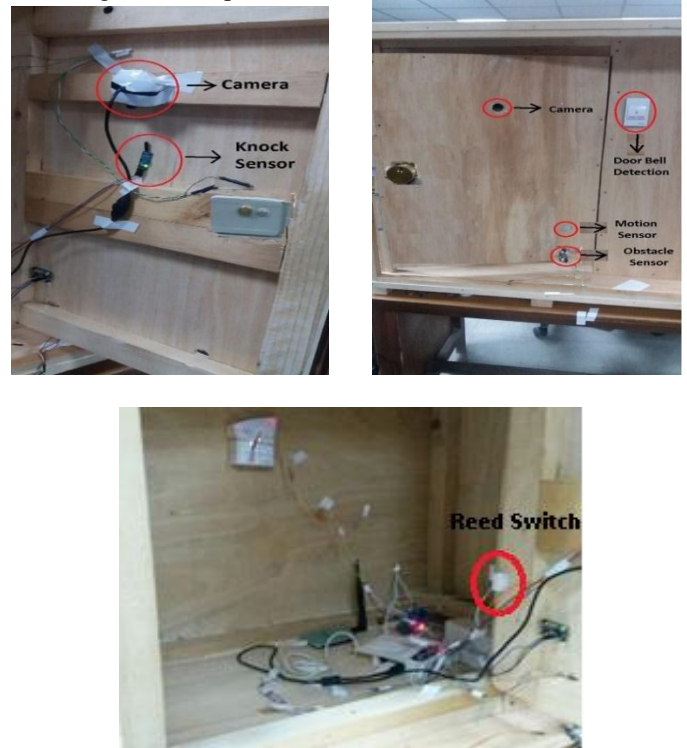

Figure 3: Device interfaced with home door lock (Prototype system developed)

This system proposes generic mobile application that can be used to monitor and control multiple electronic door locks. The application consists of an option for managing door locks where user is provided with customized settings to insert, delete, edit or disable the device connected to the door. This allows user to maintain a list of doors at the right side as a navigation menu which can be viewed by him/her. User can select the door from the list and can view the activity tab (showing images of visitors and suspicious person arrived at that door), action tab (unlock operation performed for a particular activity) and door status (open or close) accordingly. Moreover, for the ease, user can assign door names as well e.g. Front Door, Back Door, My Home Door etc. Customized app facilitates the user to add features according to the requirement i.e. Door knock, Door Bell, Human detection for Door Lock. Features can also be managed by the user i.e. insert, delete or edit as per their personal needs.

IV. RESULT
The performance of the device with sensors was tested successfully with picture clicking, storage, notification sending and door unlocking using android application.
To test the system we considered three possible scenarios.

E.   GOOGLE   CLOUD   MESSAGING   FOR NOTIFICATIONS (DOWNSTREAM MESSAGES)
For receiving notifications of visitor arrival and intruder alerts, google cloud messaging service has been employed. Google Cloud Messaging (commonly referred to as GCM) is a mobile notification service developed by Google that enables third-party application developers to send notification data or information from developer-run servers to applications that target the Google Android Operating System [12]. Firebase cloud messaging (FCM) is a newer version of GCM. The application's package name was registered at FCM console and API key was obtained to be used by server to send notifications to client applications. During the registration process, classes were made in application to register the user to google cloud messaging. Each user was identified by a unique registration token which was saved in the device (Raspberry pi) database. The device then used these tokens in the database to send notifications to registered users after image clicking.

- There is a visitor at the door who is not a family member.
- Owner himself is at the door.
- Someone has been standing at the door for a suspiciously long period of time and has neither pressed the bell nor knocked the door.

SCENARIO 1 (VISITOR AT THE DOOR)

Suppose there is a visitor at the door. He presses the switch of the bell. The bell rings.

As a result the raspberry pi got the high signal at its GPIO pin through the receiver end of the bell. The camera was enabled and it clicked the picture. The notification of the visitor was then sent to the two adults. The user when opened the notification could view the picture of the visitor. After viewing the picture the user could either ignore it or take an action. He wished to unlock the door. He entered the pin code for verification. After pin code verification user pressed the unlock button, the raspberry pi produced a high output on the pin at which relay was connected. The relay in turn unlocked the door.

If the visitor knocks the door the low on the GPIO pin enable the camera. The picture is clicked and the user is notified.

If the user wishes to check the status of the door after a few minutes to check whether the door has been closed or is it still open, he/she can easily check that through the android application. When the user clicks on the status tab, the android application asks the raspberry pi to give it the live status of the door. The raspberry pi checks the GPIO pin on which the reed switch is connected. The output indicates whether the door is opened/closed. It sends the value to the android application. The application shows the value to the user. All of this takes place in a fraction of seconds.

SCENARIO 2 (DEVICE OWNER IS AT THE DOOR)

Suppose the user himself is at the door.

He had two options. He just entered the correct pin code. After successful verification of the code the user unlocked the door by pressing the unlock button.

SCENARIO 3 (SUSPICIOUS ACTIVITY)

Suppose there is a person at the door who has been standing for more than three minutes.

The raspberry pi noticed that the GPIO pin on which the obstacle sensor is connected had been high for three minutes. The person had neither knocked nor rung the bell. This enabled the camera and the clicked picture was sent to the user's android application along with the notification, 'There might be a suspicious person at your door'. If the person wanted, he could make an emergency call after viewing the picture with the option available in the application

The owner could also view the status of the door whether it is opened or closed through the status tab.

V. CONCLUSION

After conducting experiments it was observed that the face detection algorithm from OpenCV can be used to safe only those images in database having proper face of visitor/suspicious person. An average delay of 2-3 seconds was observed in data sending and retrieval from/to application which can be reduced by using high speed internet connection. Moreover, if internet connection is not functional, GSM technology can be used to control/monitor door locks. Also as client/server architecture is implemented for our product, security techniques to encrypt passwords and ensure confidentiality, integrity and availability of data can be implemented.

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