Development of Intelligent Security Door

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Abstract: *The majority of people are afraid about their homes and personal property. And that sounds reasonable because of the time that we are living in – the uncertainty is everywhere around us. There are so much burglaries and no one is insured against them. Considering the high rate of crimes and insecuritythere are a lot of designs of doors of the highest standards of security. In this paper we present the development and implementation of innovative intelligent security door for home and office with integrated access control management system, remote monitoring and control system. All integrated systems are positioned inside the door. Also there is a set of sensors, which gives information about the state of the door at any particular moment.   The proposed security door can be locked or unlocked from any place in the world via user's mobile phone. It also can send him an information about burglary attempts. If the user is in front of the intelligent security door he can use RFID card for locking or unlocking it. The system is developed over embedded microcontroller. The paper presents the main idea of such development, the system architecture and the main functionalities.*

Keywords: smart security doors, smart home, IoT

1. Introduction

The majority of people are afraid about their homes and personal property. And that sounds reasonable because of the time that we are living in – the uncertainty is everywhere around us. There are so much burglaries and no one is insured against them. Considering the high rate of crimes and insecurity there are a lot of designs of doors of the highest standards of security.

In recent years, security door has shifted away from simple mechanical key control locking systems into innovative, high-tech systems and gadgets that compose items on many homeowners' wish lists. The new door security systems are used in commercial and government buildings, as well as in residential settings.Digital door locks have been widely used in households and offices. However, in many cases, an intruder has tried to penetrate a private area by circumventing the lock.

More recently, a variety of communication technologies have been fused to receive and provide information about things. Over the world, IoT (Internet of Things) and M2M (Machine Interpersonal Communication) technologies which were developed for smart home system are becoming well known.

Radio frequency identification, RFID is a technology that is used in many fields including locks. RFID technology is getting very popular, it is used in many areas such as public transport, ticketing, animal identification, electronic immobilizers, industrial automation, access control and many more. The question here is if existing door locks using RFID are secure enough for everyday use. What is of interest here is door locks that use active authentication of the key through cryptographic methods.

2. Literature Survey

There are a plenty of attempts to develop and implement a smart and intelligent security door systems for homes and offices. Up to date, complete security is not discovered yet.

Some research efforts have tried to connect the door to the cloud. For instance, [1] and [2] provide a door locking solution operated remotely by harnessing the power of Internet of things (IoT), which has better security features and is user friendly.

An Intelligent Door Locking System controlled by fingerprint is proposed in [3]. The built in camera and GSM modem sends a picture to the owner if someone without permissions try to unlock the door. The issue here is that the GSM modem is used only for one direction connection, so we couldn't control the door via mobile phone.

Design and Implementation of Microcontroller Based Security Door System Using Mobile Phone and External Computer is described in [4]. This solution is suitable for test and experiments but it is not suitable for mass production.

In [5] the authors are focused on Elctro-Mechanical Locking Systems. They give a critical review on existing systems and propose an innovative energy saving locking system.

Papers[6] and [7] describes the design and operation of a door locking systems using smartphones or tablets through Wireless Fidelity (WiFi) technology. Programmed using Android, the smartphone or tablet can lock and unlock the door within WiFi range. The problem in such a solution will be the existence of WiFi network and the security.

A Video based smart home security system for home security is presented in [8]. It uses a camera and Raspberry Pi module to visualize and identify people who visit the home. The idea of security is that owner can see and make a conversation with the person in front of the door. Based on Time Zone Locking system for security rooms is developed in [9].

3. Proposed System

The proposed intelligent security door will has a lot of new and innovative functionalities. First, all parts of the system are integrated into the door. The RFID reader, the mobile phone module, the set of sensors, the alarm module, etc.

This made the proposed security system invisible. This functionality increasesthe security level of the door, because no one from outside knows what exactly is hidden into the door. In all other systems there is one or more modules that are visible (keypad, RFID reader, etc.). When the module is visible the person who attacks the door know exactly what is "hidden" behind it and is easy for him to overcome the door. But when there is nothing visible the attacker will be embarrassed.

The second functionality is the automatic locking mode of the system. This means that when you lock the door it automatically locks. So the user will never ask himself the question "Did I lock the Door?".

RFID card access control of the door is the next functionality. The door could be locked or unlocked by RFID contactless card.

The door could also be controlled via mobile phone. The new functionality is the feedback from the door. The integrated security system is sending short messages (SMS) to the administrator of the door when there is an attempt to unlock or open the door.

The two level blocking system is a functionality that makes the door more secure. The idea of this two level blocking system is that the user should use two different types of "keys" to unlock or lock the door.

The door also has an integrated alarm system which should indicate with a sound when there is an attempt to unlock or open the door from unauthorized person.

4. Implementation

The system architecture of the proposed intelligent security door is shown on figure 1. All modules that are in Intelligent Security Door System block are integrated inside the door and are invisible form outside. The set of sensors consists of four sensors – Vibration, Magnetic, Mechanical Lock and Electro-Mechanical Lock sensors. Vibration Sensor is an active sensor with built-in microcontroller which measures the level of vibrations into the door, analyze them and sends information to the embedded microcontroller. The sensing level of the sensor could be set by the user via mobile phone SMS. The firmware that runs into the built-in sensor microcontroller have a neural network module and makes a long term measurement of the vibrations so it can make a difference when the vibration is caused by the intruder or repeated influence (elevator, blowing wind etc.).

The Magnetic Sensor has two functions. First of all it should "tell" to the main logic (embedded microcontroller) that the door
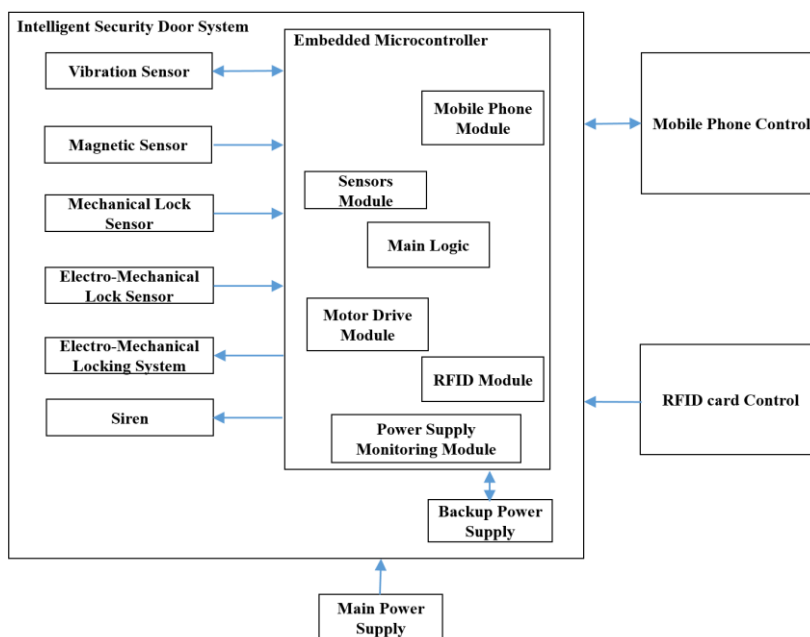

Figure 1: Intelligent Security Door System Architecture

is closed. This is important when the door is in automatic mode and should locks. The second function is an alarm function when the door is closed, locked and someone tries to open it by force or other unallowed way.

The Mechanical Lock Sensoris mounted nearby mechanical lock system and shows its position – locked or unlocked. The information from this sensors is used by two modules in microcontroller. First this information is used to inform the microcontroller that there is an authorized unlocking. Second this information is needed for the two level blocking

system. When the door is locked with electro-mechanical locking system and with mechanical one the RFID card control of the door is forbidden. The user must first unlock the door via mechanical key and after that to unlock the electro-mechanical locking via RFID card. This is so called two levelblocking system – the mechanical locking system blocks the electro-mechanical one.

The Electro-Mechanical Locking Sensor is the same as mechanical one and has the same functions – information for unauthorized unlocking and two level blocking system.

The Electro-Mechanical Locking System is the main secure module of the whole system. It consists of a linear actuator and mechanical locking switches. The linear actuator is a 12V small size actuator with a thrust loads up to 3000N. This parameters guaranteed the security level of the proposed intelligent door.

Siren is the module that makes an alarm sound when the unauthorized attempts for opening the door are detected. It is also built-in inside the door and is invisible from outside. The same siren but with low level sound is also used for indication when the changes of door settings are made by the administrator.

The Backup power supply is integrated into the door battery. It should give the door the needed power when the external power supply is down. The software of the embedded microcontroller is watching for proper levels of external and backup power supply and informs administrator via SMS if there is a low level situation.The Backup powers supply is designed to guarantee 24 hours of work for the system.

The "heart" of the system is embedded microcontroller with firmware that runs on it. The firmware is developed as a hierarchical state machine. The main modules of it are show on figure 1 – Main Logic, Sensors Module, Mobile Phone Module, RFID Module, Motor Drive Module and Power Supply Monitoring Module. The Sensors Module communicate with all sensors, receive information from them and takes decisions for the state of the door, proper working of all integrated modules and alarm states.

Power Supply Monitoring Module uses the built-in microcontroller ADC ports and measures the voltage and current of the main and backup power supply. If there is a low level states the module send information to Mobile Phone Module and Main Logic to inform administrator via SMS and with a sound for this state of the door.

Motor Drive Module is that part of firmware that drives the Electro-Mechanical Locking System. It use information received by Sensors Module, RFID Module and Mobile Phone Module and takes decision how to drive the locking system.

RFID Module is in charge of communication with RFID card. It is responsible for decrypting and decoding the information received by RFID card.

Mobile Phone Module is responsible for communication with the users via mobile network. This communication is a duplex communication. From one side the user could control (lock or unlock) the door, gives or take away access to the door via mobile phone or RFID card, configures the parameters of the door, etc. From the others side the door informs the user when tha door is locked or unlocked, when there is an alarm situation or power down, etc.

The Main Logic is that part of firmware which makes connection between all other modules and reads and writes data in the EEPROM memory
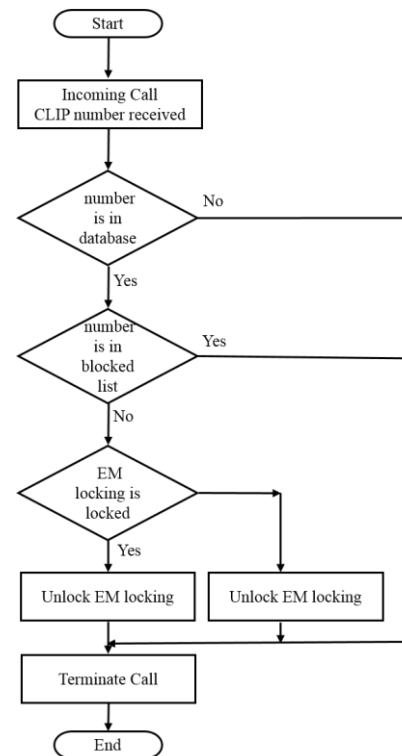

Figure 2: Mobile Phone Door Control

The algorithm of mobile phone control over the door is given on figure 2. When the door with integrated mobile phone module and SIM card receives an incoming call, the Mobile Phone Module takes the calling number using the CLIP function. After that this number is queried through the database. If there is such number in the database, a check for block list numbers is applied. If the number isn't blocked the system checks the state of the electro-mechanical locking system and if the door is locked it will give a command to unlock it. If the door is unlocked it will give a command to lock it. The call termination is the last step. If the calling number doesn't have access to the door we directly go to call termination.

The algorithm of RFID card control over the door is given on figure 3. When a RFID card is detected the card ID is queried in the database. If the card have access the Blocking System check is performed. If the mechanical locking system is in lock state a sound signal is generated. If the mechanical locking system is in unlocked state then the state of electro-mechanical locking system is checked. If it is in unlocked state the locking command will be given. If it is in locked state the unlocking command will be given.
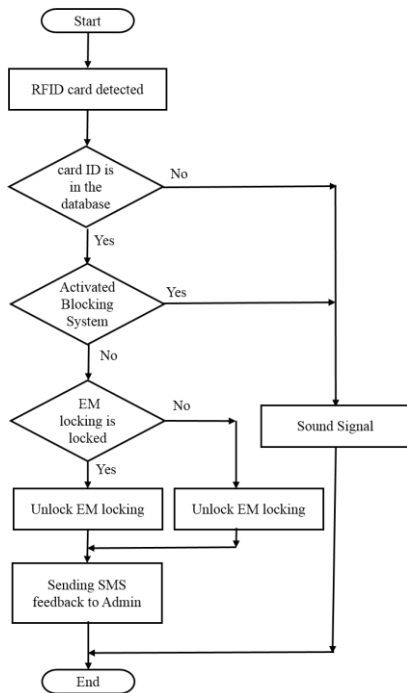
Figure 3: RFID card door control

On figure 4 a SMS with main setting of the intelligent security door are given. With the command SV from administrator's mobile phone an information about the state of the door is inquired. The response shows the states of the mechanical, electro-mechanical, magnetic and vibration sensors. If the state is 1 the sensor is activated, otherwise it is not activated. The voltage of the main power supply and the mobile module signal level are also given. Next information is about the mode of the door – automatic or manual locking, the time delay before automatic locking, the alarm time delay and the time interval for alarm sound. The quantity of RFID cards that have access to the door is also given. The Feedback from the door could be switched ON and OFF. Finally the number of locking and unlocking cycles are given.

Figure 4: SMS with current door state

5. Conclusion

In this paper a development of intelligent security door controlled by mobile phone and RFID card was proposed. The proposed door increases the security level of the users and will gives them the ability to control the door access from any point of the world via mobile phone control.

References

[1] Neetu Gupta, Ritabarta Mandal, Vinay Chaddha, "Internet of Things based Door LockingSystem–An Architecture",Press. IJCTA,9(20), 2016, pp. 385-390
[2] OhsungDoh, Ilkyu Ha, "A Digital Door Lock System for the Internet of Things with Improved Security and Usability", Advanced Science and Technology Letters Vol.109 (Security, Reliability and Safety 2015), pp.33-38
[3] B. Anubala, M. Rahini, T. Bavithra, "Intelligent Door Locking System",International Journal of Engineering Research and Applications (IJERA), International Conference on Humming Bird (01st March 2014), pp.50-53
[4] Nwankwo Prince. N, NsionuIfeanyi. I., "Design and Implementation of Microcontroller Based Security Door System (Using Mobile Phone & Computer Set)", Journal of Automation and Control Engineering, Vol. 1, No. 1, March 2013, pp. 65-69
[5] Sivarao, Abdul Alif, Taufik, Yuhazri, Haery Ian, Robert K. M., Tin S. L., "Critical Review of Electro-Mechanical Door Locking System and Proposal towards Development of Innovative Super Energy Saving Door Locking System", International Journal of Engineering and Innovative Technology, Volume 2, Issue 5, November 2012, pp.201-207
[6] N. Hashim, N. F. A. M. Azmi, F. Idris and N. Rahim, "Smartphone Activated Door Lock Using WiFi" ARPN Journal of Engineering and Applied Sciences, vol. 11, No. 5, March 2016, pp. 3309-3312
[7] Anuradha.R.S, Bharathi.R, Karthika.K ,Kirithika.S, S.Venkatasubramanian,, "Optimized Door Locking and Unlocking Using IoT for Physically Challenged People", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 4, Issue 3, March 2016, pp. 3397-3401
[8] BurakSarp., TolgaKaralar., "Real Time Smart Door System for Home Security", International Journal of Scientific Research in Information Systems and Engineering Volume 1, Issue 2, December-2015, http://www.ijsrise.com
[9] Safaa A. Mahdi, "Development Of Anti-Theft Door System For Security Room", SAVAP International,Natural and Applied Sciences, Vol. 4 No. 3 May 2013, pp. 237-242

Author Profile

Georgi Balabanov received PhD degree in Communication Networks and Systems from Technical University of Sofia. He is currently Assistant Professor at Department of Telecommunications, TU Sofia and Affiliate researcher at TeleInfrastructure R&D Laboratory. His main research interest includes broadband communication network, queuing theory, IoT and AAL.