A decentratlized strong authentication access system based on rfid, face recognition and raspberry pi

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ABSTRACT: Access to most secure areas is controlled with use of mechanical lock and key. The objective of this paper is to design a secure door access system using face recognition, raspberry pi and RFID, with capability of data collection and treatment. In this paper, we present three sub-systems that is a system to read, write and protect data on RFID card using raspberry pi and RC522, (The face recognition module has been successfully tested on students attendance) then a decentralized secure access system using the above components with the single addition of a stepper motor which functions as an actuator, finally a web platform to remotely access user data log. Radiofrequency identification (RFID) is a technology that uses radio waves to transfer data from an electronic tag, called RFID tag or label, attached to an object, through a reader for the purpose of identifying and tracking the object. In our case, it is used to identify a person. When the holder of the tag places the card near the reader, the information is read and cross-referenced in the database for authenticity. If the information is validated, then the door opens and the data timestamped and saved in a local and online server, else the door remains locked. Using RFID tag is more accurate than other biometric means of its high authentication because of its accuracy of detection.

Keywords: RFID, Raspberry pi, RC522, stepper motor, biometric data.

INTRODUCTION

In most African countries and in Cameroon in particular, access to buildings is done through the use of a lock and a key. This system over the years has proven to be ineffective due to a good number of issues it fails to address. For example, entry and exit of building is a process which produces data, which when analyzed latter can help in investigations and provide quick statistics to study and predict human behavior in big businesses so as to increase productivity and equally offer the optimum level of protection.

Again, the keys are easily losable and considering the fact that most keys are out of metals, it is expensive to replicate hence it is not cost effective. It is against this backdrop that we design a decentralized access system based on RFID and raspberry pi to address these issues. Radio frequency identification (RFID) is a matured technology that incorporates the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object, animal, or person.

They are grouped under the automatic identification (Auto-ID) technologies (1). Because RFID offers a high degree of accuracy, we prefer to use it over the other Auto-ID technologies.

Some of these auto id technologies include fingerprint, DNA analyzer, palm, iris and others. The overall block diagram is shown in Figure 1.

METHODOLOGY

The development of this system was done in three phases, namely programming of tags or cards, development and implementation of a door access system and system management software.

Programming of RFID cards/tags

The goal of this phase is to be able to write user personal information to the tag, again to read and protect it. First, the apparatus to read/write is setup consisting of raspberry pi and RC522 module, and the program to manage the read/write process installed. When the tag come within the reading range of the reader, all information in the tag is read and modified to user personal information. The read range *r*can be calculated using the Friis free-space formula

$$r = \frac{\lambda}{4\pi}\sqrt{\frac{EIRPG r\tau}{Pchip}} \quad (2)$$

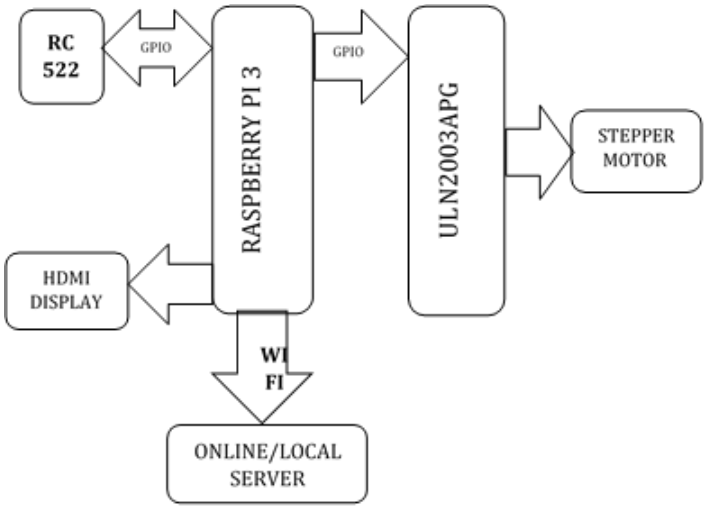

Figure 1: Overall Block diagram

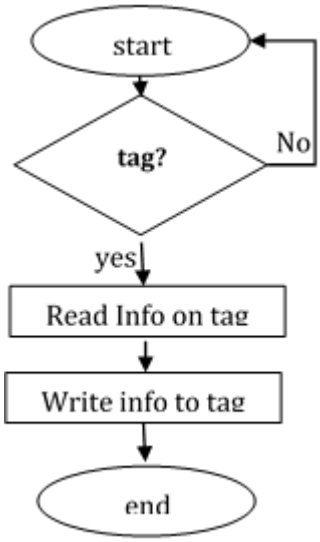

Figure 2: Flow diagram of Programming of RFID cards/tags

Where λ is the wavelength and EIRP is the equivalent isotropically radiated power, usually determined by local country regulations example in Europe EIRP = 3.3W AND 4W in USA. P_{chip} is minimum threshold power necessary to activate the RFID chip, G_r is the gain of the receiving tag antenna, and τ is the power transition coefficient between the chip and the antenna.The flow diagram below shows the flow of activities during this phase

Development and implementation of a door access system

This phase consists of assembling all the required components (raspberry pi, ULN2003APG, stepper motor, and RC522) with jumper wires, and executing a program to make all these components function to achieve access security. The program is written in python and is configured to run automatically during start-up of the raspberry pi.

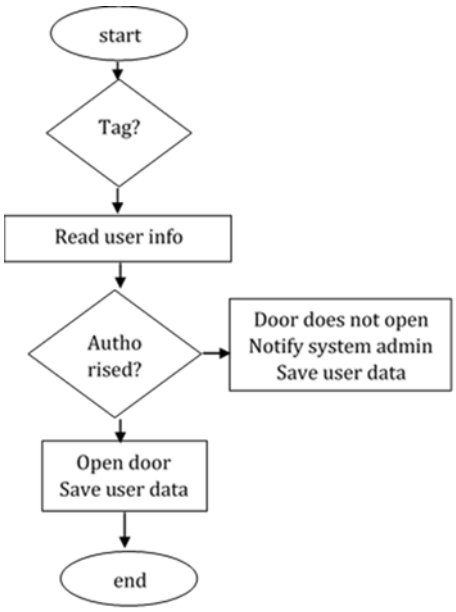

Figure 3: Development and implementation of a door access system

The flow diagram below illustrates the sequence of activities in this phase. When the tag comes within reading range of the reader, the information is read and cross referenced in the database. If user is authorized, the door opens else the door remains closed and the system administrator notified. In either of the above cases, the user data is stored in a local and an online server.

System management software

In this phase, we develop a web platform using php, html, ajax, JavaScript, jQuery and others, thereby granting the system administrator remote access to the data collected in real time. The platform shall be used to perform queries, and the result of the queries used for investigation.

HARDWARE DESIGN

The hardware configuration of this system is mainly composed of a raspberry pi, RC522, UNL2003APG, stepper motor.

Raspberry pi

Raspberry pi is a credit- card sized computer. It functions almost as a computer (3). It also contains components like SD Card Slot is used to install OS/booting/long term storage, HDMI OUT (High Definition Multimedia Interface) is used with HDTVs and monitors with HDMI input, GPIO allows us to control and interact with real world, Micro USB Power Port, RCA Video Out, Audio Out, Ethernet Port and others.

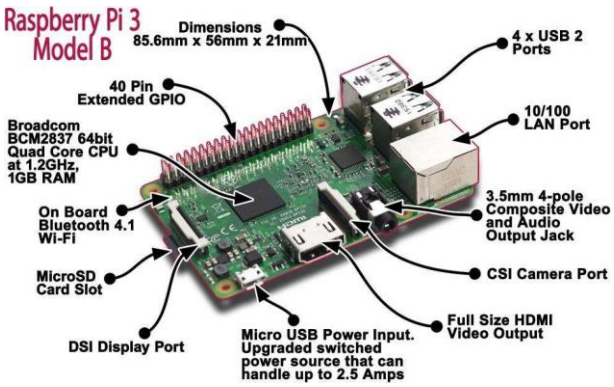

Figure 4:Raspberry pi Model B

Other boards like Arduino could also be used. But because of the high computational need of our system be prefer raspberry pi. The table below gives a brief comparison.

Variable/ Characteristics	Raspberry pi	Arduino
Internet Connectivity	Very Easy	Difficult
Processing Capability	Run multiple programs simultaneously	Run a single program repeatedly
Battery Support	Difficult	Easy
Complexity Support	Support more complexity	Support less complexity
Cost	Expensive	Less Expensive
Processor Family	ARM	AVR
Software Orientation	Highly oriented	Lowly oriented
Hardware Orientation	Lowly oriented	Highly oriented

Table 1: Comparison between raspberry pi and Arduino

RFID tag/card

Radio Frequency Identification (RFID) has a long history and is part of the technological revolution both current and past. RFID enables quick payment of tolls and quick identification of items. In addition, RFID provides benefits, such as tracking assets, monitoring conditions for safety, and helping to prevent counterfeiting. RFID plays an integral part in the technological revolution along with the Internet and mobile devices, which are connecting the world together (4).They are quickly overtaking and replacing the traditional bar-code system because of the numerous advantages they present.

Figure 5: Different shapes and sizes of RFID tags

There are two types of tags namely active tags and passive tags. They operate differently but carry the same information known as EPC-Electronic Product Code. This is a product numbering system that uses an additional set of numbers compared to barcodes and as-signs each item manufactured with a unique product identification number. The EPC system is linked to an online database that increases the opportunity for information sharing (5). Table 2 shows some major comparisons between the two.

Variable/ Characteristics	Passive tag	Active tag
Power	No power needed	Powered by an internal battery with finite lifespan
Range of detection	Short	Long
Interference	Sensitive	Less sensitive
Transmission rates	Low data transmission	High data transmission
Card readability	Can read few at once	Can read many at once
Precision	Reader needs to be aimed at the tag	Tags can be read without precise aiming

Table 2: Differences between Passive and Active tags(5).

RC522

A component that can read and write RFID tags with a frequency of 13.56 MHz (6).

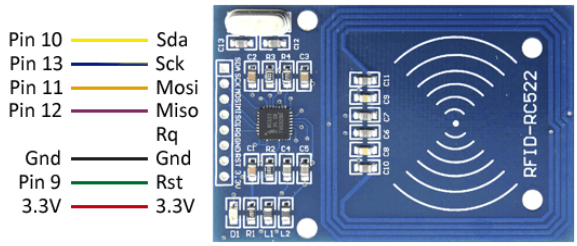

Figure 6:RC522 reader/writer

ULN2003APG and Stepper Motor

Stepper motors are commonly used in precision positioning control applications. Five characteristics of the stepper motor have been considered while choosing stepper motor for the solar tracker prototype. Stepper motor is brushless, load independent, has open loop positioning capability, good holding torque and excellent response characteristics. A typical controller for a hybrid stepper motor includes:

(i)Logic Sequence Generator: -Generates programmed logic sequence required for operation of stepper motor.

(ii) Power Drivers: -These are power switching circuits which ensure a fast rise of current through the phase windings which are to be turned on at a particular step in the logic sequence. ULN2003 stepper motor driver has been used in the prototype.

(iii) Current limiting circuits: -These are meant to ensure a rapid decay of current in phase winding that is turned off at a particular step in the logic sequence(7).

Figure 7: ULN2003APG and Stepper Motor

IMPLEMENTATION

Two main connections are done in this system. One between the raspberry pi and RC522 which permit the reading and writing of data, and the other between the raspberry pi and the ULN2003APG, which in turn is connected to the stepper motor. First the figure below shows the structure and design of the entire system, taking into consideration the online server.

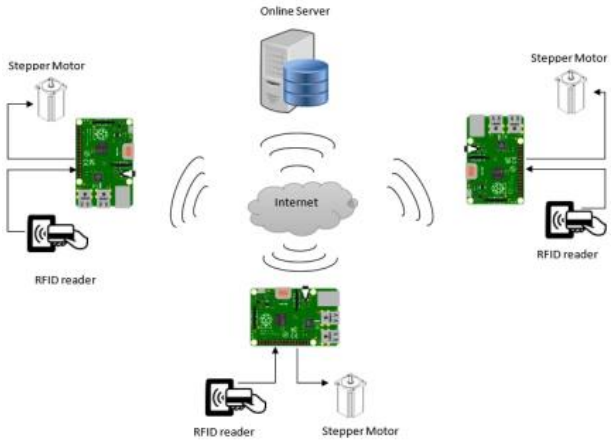

Figure 8: Structure and Design of the system

The following tables show the interconnection between the GPIO pins and the colored female jumper wire used.

RFID	RASPBERRY PI	GPIO PHYSICAL PINS	WIRE COLOR
SDA/SS	CEO	24	Green
SCK	SCLK	23	Blue
MOSI	SPI MOSI	19	Purple
MISO	SPI MISO	21	Grey
IRQ	N/C	N/C	N/A
GND	GND	6	Black
RST	GPIO 25	22	Brown
3.3V	3.3V	1	Red

Table 3: Interconnection schematic between RC522 and Raspberry pi GPIO pins

ULN2003APG	GPIO PHYSICAL PINS	WIRE COLOR
IN1	29	Red
IN2	31	Green
IN3	33	Blue
IN4	35	Orange

Table 4: Interconnection schematic between GPIO Physical pins and wire color

After connecting all the components together, a system like the one below is obtained.

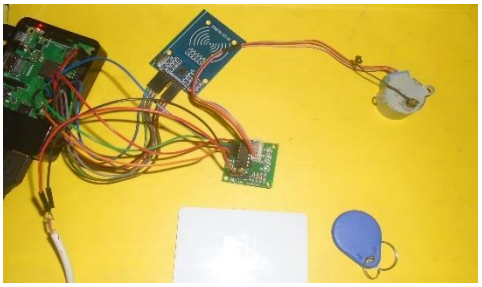

Figure 9: Interconnection of components

RESULTS AND DISCUSSION

The overall decentralized access security system is programmed with python and its web interface with php, html, JavaScript, ajax and jQuery. We developed an RFID system capable of reading and writing data to tags. After successfully writing user data to a tag, the data blocks are blocked then encrypted for safety purposes. Next, we successfully implemented the locking mechanism based on RFID and raspberry pi. We carried out a series of test on the system so as to observe the performance as shown on table below.

Observation	RFID unit	Door Open	Door Close	Data Capture
01	Success	Success	Success	Success
02	Failure	Failure	Failure	Failure
03	Success	Fail	Fail	Success

Table 5: Performance Test

From the above test, we observe that when the tag is registered in the database, the door opens else it remains locked. The second case suggests that the tag is non-functional and undetectable by the reader.

CONCLUSION

In this paper, a decentralized system is presented that controls access with use of RFID tag and raspberry pi and a stepper motor as an actuator. This system can be further upgraded by using the timestamped log data to control other events such as services in a hotel. Again, it can be easily modified to take attendance of employees or of students in academic environments.

Part 2- know-how transfer

The Problem solved should be clearly defined
Access to specific areas should be protected and authorization should be given only to those who are supposed to be there at a specific moment of time. The lock and a key system over the years has proven to be ineffective due to a good number of issues it fails to address. The strong authentication proposed is to use biometric data and also a specific given information that can be overridden at anytime.
Fully description of the methodology used
The methodology is to use the Python Open CV library and many other libraries for face recognition based on the list of faces that were pre recorded in a MySQL database. In order to avoid the well-known limitations on such a technique, we add a what you are a what you have leaving a side the what you know that can be added to the project if a customer requires.
Description of the technology and know-how required for the successful transfer
The written scripts are in Python and many other languages specifically for the RFID tag that is issued only to those that should have. A camera that is not always an IP camera is suitable and a firewire or USB interface is acceptable by the Raspberry Pi 3 nanocomputer. The RFID card writer/reader and a card itself is for each user. The server that can use the LAN or WLAN permits to connect to the server where an interface is buit an allows to visualize all kind of statistics.
Description of all steps required to achieve marketability

The first step is to identify those who need to protect an asset for access authorization. They can be Bank system, Government documents protection at court, police, military zone, etc.
After we have identified the needs of the customer,
A comparison with the current system can be done and the subject under test by us can be proven to be ineffective. If such a situation occurs, we propose our system that comprises the following.

Description	*Price*
Server	*1500000*
Wireless router	*100000*
RFID Reader	*100000*
RFID Cards	*100000*
Camera	*50000*
Necessary cables	*4000000*
Workmanship	*2000000*
Script Licences	*2000000*
Total Taxes Free	*9 850 000*

REFERENCES

1. *Radio frequency identification (RFID) based attendance system with automatic door unit.* Chiagozie, Ononiwu G and Nwaji, Okorafor G. 2, s.l. : SAVAP International (Society for the Advancement of Education through~…, 2012, Academic Research International, Vol. 2, p. 168.

2. *Chipless \RFID and wireless sensors based on planar magneto inductive-Wave (MIW) Delay lines.* F.J. Herraiz-Marinez, F. Paredes, G. Zamora, F. Martin, J. Bonache, D. Segovia-Vargas. Espana : Union cientifica International le radio (URSI), 2012. Elche.

3. *Smart surveillance monitoring system using Raspberry Pi and PIR sensor*. Prasad, Sanjana and Mahalakshmi, P and Sunder, A John Clement and Swathi, R. s.l. : Citeseer, 2014, Int. J. Comput. Sci. Inf. Technol, Vol. 5, pp. 7107--7109. 6.

4. *Application of RFID technology for logistics on internet of things.* Sun, Chunling. s.l. : Elsevier, 2012, AASRI Procedia, Vol. 1, pp. 106--111.

5. *A comparison of barcoding and RFID technologies in practice.* White, Gareth and Gardiner, Georgina and Prabhakar, Guru Prakash and Abd Razak, Azley. s.l. : Informing Science Institute, 2007, Journal of information, information technology and organizations, Vol. 2, pp. 119--132.

6. *Implementation of Web \& 13.56 MHz RFID Card based Attendance System (Case Study: ITB Attendance System).* Purnama, Adi.

7. *Solar tracking system using stepper motor*. Anuraj, Ankit and Gandhi, Rahul. 2014, International Journal of Electronic and Electrical Engineering, Vol. 7, pp. 561--566.