Vietnamese - German University

ECE2021 Smart Building Project Proposal

Mini Smart House

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1. Introduction

1.1. Problem Background

The idea of traditional locks and keys has changed significantly in an era marked by fast technological developments. Smart locks, often known as electronic locks, are a cutting-edge way to improve convenience and security in residential settings. Without the need of actual keys, these electrical locks use electronic identification techniques to grant entry to the premises. Modern electronic locks are equipped with a plethora of advanced functions, such as Bluetooth or Wi-Fi networking, password authentication, fingerprint recognition, and remote control.

Moreover, we investigate the integration of motion sensors for the purpose of automatically turning on lights in the hallway. This effectively addresses a critical security concern by removing regions that may be dangerous or dark. Homeowners may accomplish a comprehensive approach to domestic security that strikes a balance between convenience and safety by integrating these cutting-edge technologies.

Today with climate change, the temperature rose significantly, installing auto cooling systems by using fans and humidity sensors to keep the house in a flexible environment for homeowners' health and comfortable feeling.

1.2. Objective

In this project, we use a capacitive fingerprint sensor instead of an optical sensor for security purposes. This will be installed on the door and connected to a circuit board in the hallway. The motion sensor we use will be a PIR sensor because of its high accuracy and affordable cost. Also, a temperature and an LCD to show room temperature will be installed inside.

1.3. Requirements and Specifications

PART	PRICE/UNIT	QUANTITY	TOTAL PRICE
Arduino UNO R3 V3	155.000VND	2	310.000VND
Jumper Wire (40)	28.000VND	2	56.000VND
Electric Lock	120.000VND	1	120.000VND
Relay Opto (5V)	20.000VND	4	80.000VND
12V DC Adapter	40.000VND	1	40.000VND
Bucking circuit (5V -> 3.3V)	6.000VND	2	12.000VND
Bucking circuit (12V -> 5V)	30.000VND	1	30.000VND
ESP32 WROOM	215.000VND	1	215.000VND
R503 Capacitor Fingerprint Sensor	413.000VND	1	413.000VND
Push button	6.000VND	4	24.000VND
Buzzer circuit	10.000VND	1	10.000VND
Digital PIR motion Sensor	103.000VND	1	103.000VND
Light Bulb (~220V)	80.000VND	1	80.000VND
Hinge and jack	25.000VND	1	25.000VND
Led RGB 5MM Katot Chung	3.500VND	3	10.000VND
5V Fan (small)	40.000VND	1	40.000VND
Boost Converter Circuit (3.3V -> 5V)	20.000VND	1	20.000VND
BreadBoard MB-102 **830** holes	25.000VND	2	50.000VND
BreadBoard MB-102 **400** holes	16.000VND	1	16.000VND
DHT22 Temperature Humidity Sensor	107.000VND	1	107.000VND

Screen Text LCD1602 (green)	28.000VND	1	28.000VND
LCD1602 to I2C Interface Converter Circuit	16.000VND	1	16.000VND
5V Fan (big)	65.000VND	1	65.000VND
Resistor (330 and 1k ohm)	10.000VND	1	10.000VND
Fomex and craft	220.000VND	1	220.000VND
Another	100.000VND	1	100.000VND
Total		2.200.000VND	

Power supply:

In order to maintain the operation of the machine and its associated hardware peripherals, the presence of a power source is essential.

Arduino Uno R3 V3:

The Arduino Uno R3 V3 is a popular open-source microcontroller board, known for its versatility and ease of use. It is based on the ATmega328P microcontroller and features a wide range of digital and analog input/output pins, making it suitable for various electronics projects.

Parameter	Value/Range
Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Digital I/O Pins	14 (of which 6 can be used as PWM outputs)
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (of which 0.5 KB is used by the bootloader)
SRAM	2 KB
Clock Speed	16 MHz

Electric Lock:

Electric lock powered by a 12VDC source.

Parameter	Value/Range
Operation Voltage	12 VDC
Current Consumption	0.8A
Reaction Speed	< 1s

Buzzer:

A buzzer is intended to signal users when their access is denied, with this notification being conveyed through a digital signal from the microcontroller.

Parameter	Value/Range
Operating Voltage	3.3 ~ 5VDC
Operating Current	20mA
Sound Amplitude	up to 100dB.
Signal	PWM
Trigger Signal	LOW-Edge-Trigger

Button:

A small low-cost button to activate a part of the circuit.

Relay Module:

A relay functions as an electrically operated switch designed for the control of devices and systems that operate with higher voltage levels. The primary function of a relay module is to toggle the power supply of electrical devices and systems, facilitating their activation or deactivation.

Parameter	Value/Range
Voltage	5VDC
Current	200mA
Signal	HIGH(5V-DC)/ LOW(0V-DC)
Safety Close at	250VAC-10A / 30VDC - 10A

PIR Sensor:

PIR (Passive Infrared) motion sensors are pivotal devices in the realm of electronics and security systems. These sensors are designed to detect changes in thermal radiation within their field of view, making them exceptionally adept at detecting human and animal motion.

Parameter	Value/Range
Voltage range	3V–5V
Detecting angle	100 degree
Detecting distance	3.2m-12m

Response time	< 1s

Fingerprint Sensor:

Capacitive fingerprint sensors work by placing a series of capacitors under the surface of the sensor. When a finger is placed on the sensor, the ridges and valleys on the fingerprint create a slight difference in capacitance between the capacitors. This difference in capacitance is measured by the sensor and used to create an image of the fingerprint.

Parameter	Value/Range
Type	Capacitive fingerprint
Operating Voltage	3.3VDC
Operating Current	20mA
Resolution	508 DPI
False Accept Rate (FAR)	<0.001%
False Reject Rate (FRR)	<1.0%
Interface	UART (TTL) serial
Storage Capacity	200 fingerprints
Scanning Speed	< 0.2s
Verification peed	< 0.3s

ESP32 Module:

As a powerful microcontroller, the ESP32 offers a unique blend of Wi-Fi and Bluetooth connectivity, making it an ideal choice for this context.

Parameter	Value/Range
Type	System on a chip (SoC)
Wi-Fi	802.11 b/g/n @ 2.4 GHz
Bluetooth	Bluetooth V4.2 BR/EDR & Bluetooth LE specification
Flash Memory	4 MB
SRAM	520 KB
Operating Voltage	3.3 V

Humidity Sensor:

Humidity sensors, also known as hygrometers, are electronic devices that measure the amount of moisture in the air. They are commonly used in a variety of applications, including weather stations, HVAC systems, and industrial processes.

Parameter	Value/Range
Power supply	3~5VDC
Current consumption	2.5mA max (during data transmission)
Humidity range	0-100%RH
Humidity accuracy	2-5%
Temperature range	-40 to 80°C
Temperature accuracy	±0.5°C
Maximum sampling rate	0.5Hz (once every 2 seconds)
Number of pins	4
Pin spacing	0.1"

LCD:

A type of flat-panel display that is commonly used in televisions, computers, smartphones, and other electronic devices. LCD screens are known for their high image quality, low power consumption, and wide viewing angles.

Parameter	Value/Range
Operating Voltage	5V
Dimensions	80 x 36 x 12.5 mm
Display Color	Black characters on a green background
Pin Spacing	0.1 inch (convenient for Breadboard connections)
Pin Names	Printed on the back of the LCD screen for easy wiring
Backlight	LED backlight, can be controlled with a variable resistor or PWM for power-saving brightness adjustment
Signal Control	Can be controlled with 6 signal wires
I2C Model Support Communication LCD1602	Vcc = 5V-DC, GND, SDA, SCL

Fan and LED:

Low-cost fan and LED.

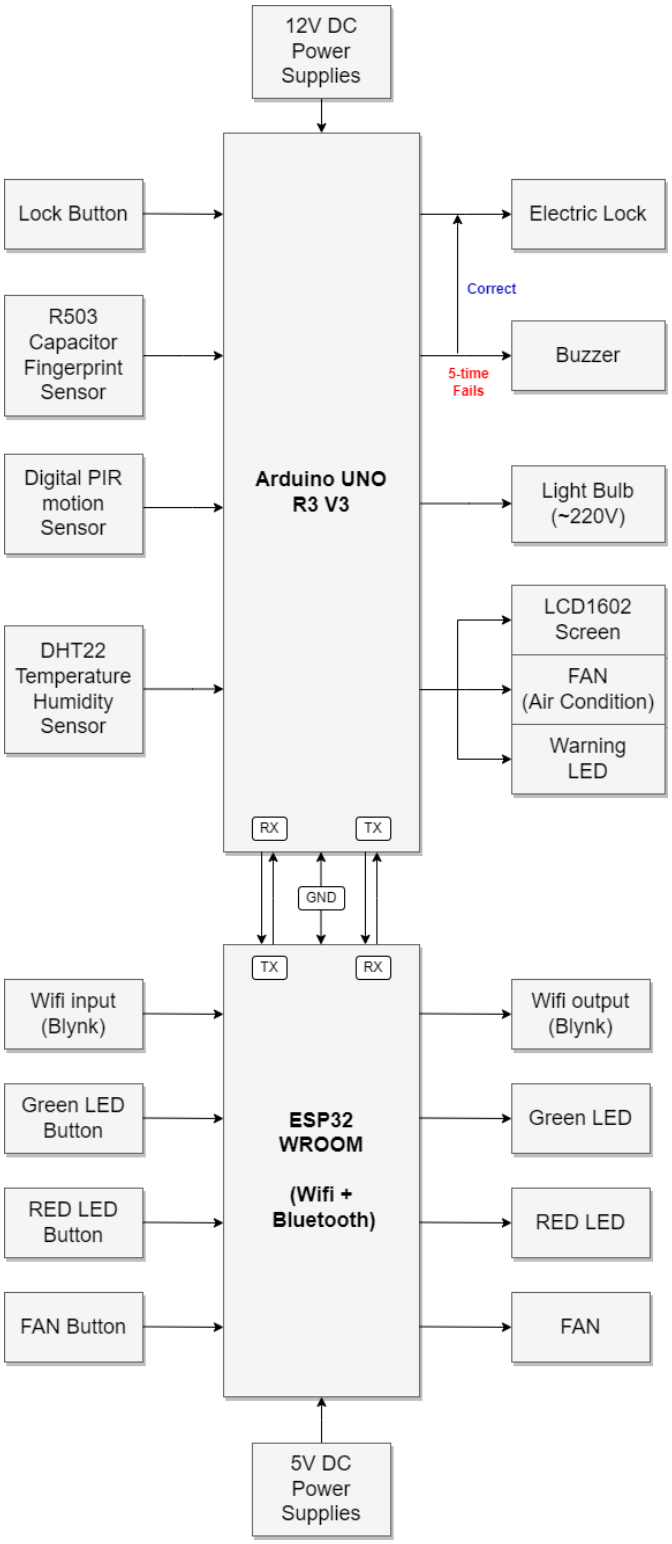
See our materials' datasheets on Google Sheets for more details: Materials' DTS

2. Statement of work

2.1. System Description

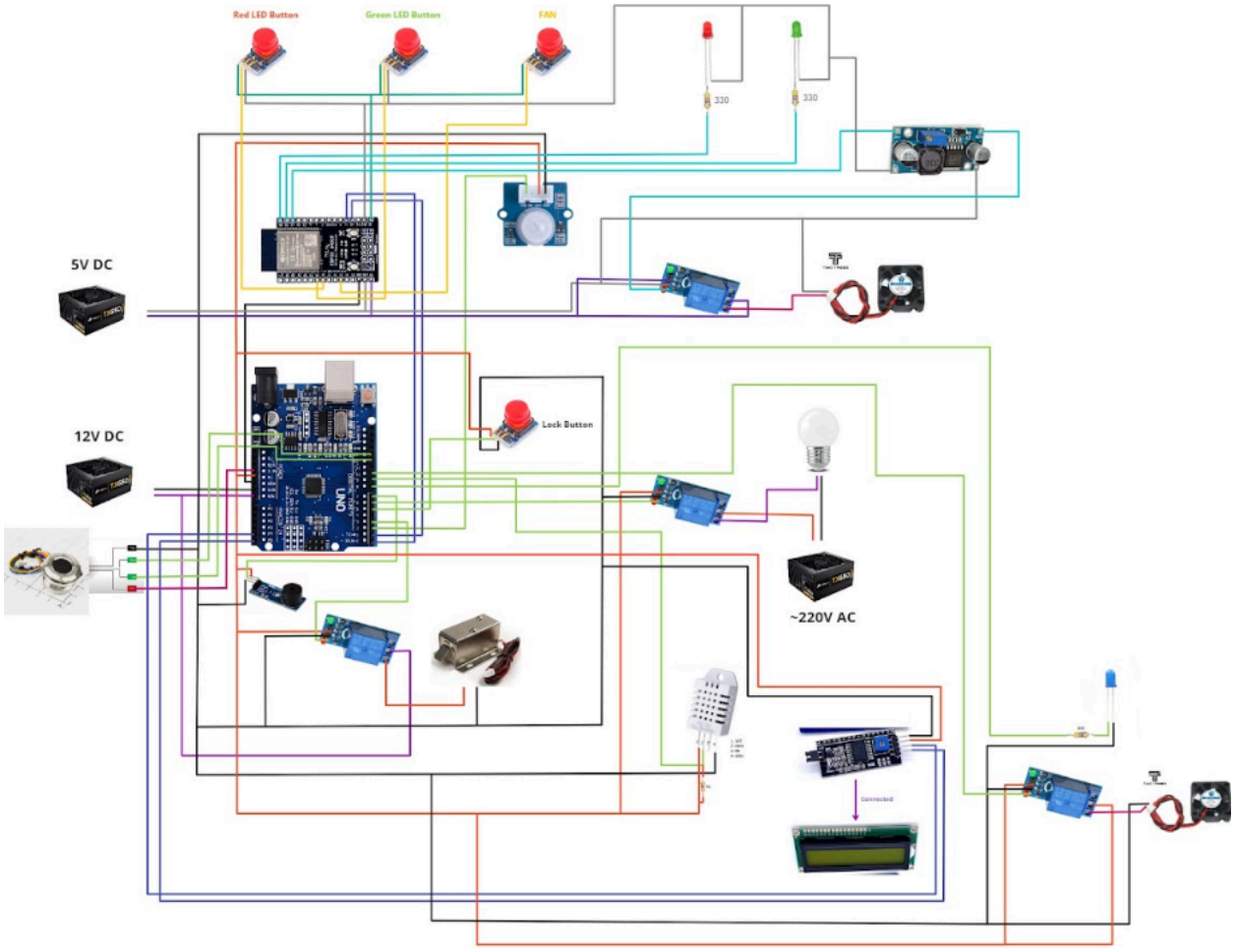
Our project will have an Arduino UNO on the backside of the door attached to a board of an electric lock, a small button, a relay module, an ESP32 module. These will be attached to a PIR sensor and LEDs on the ceiling. Another Arduino UNO will be used for connecting to a humidity sensor which will detect room temperature and be shown on a LCD screen, then adjust the room temperature by turning a fan on a wall. The frontside of the door will have a fingerprint authenticator and a buzzer, which will be wired through the door.

Below is a block diagram of our project:


12V DC Power Supplies
Lock Button
R503 Capacitor Fingerprint Sensor
Digital PIR motion Sensor
DHT22 Temperature Humidity Sensor
Arduino UNO R3 V3
RX
TX
GND
Electric Lock
Correct
Buzzer
5-time Fails
Light Bulb (~220V)
LCD1602 Screen
FAN (Air Condition)
Warning LED
TX
RX
Wifi input (Blynk)
Green LED Button
RED LED Button
FAN Button
ESP32 WROOM
(Wifi + Bluetooth)
Wifi output (Blynk)
Green LED
RED LED
FAN
5V DC Power Supplies

2.2. Design Approach

This system will put a lot of pressure on an Arduino, that's why we use 2 instead of 1. 1 will be used for controlling the PIR sensor and the fingerprint scanner and locker, the other will be used to control the humidity sensor and the LCD screen. The power supply We will use 220V so we will need the relay module in nearly every part of the circuit.



Circuit Design

Circuit designing is a very important skill to maintain a current inside the circuit and to not break electrical devices. The system will be programmed in Python on Arduino IDE 2.0.2. A smartphone application will be Blynk to develop Wi-Fi communication.
See our circuit design on website for more details: Circuit Design

Below is our wiring tables:

Arduino UNO R3 V3			
Pin Name	**Pin Number**	**Input/Output**	**Description**
RX (<-)	0	Digital I/O (Input)	UART Communication with TX of ESP32
TX (->)	1	Digital I/O (Output)	UART Communication with RX of ESP32
D2	2	Digital I/O (Input)	Grove-Digital PIR Motion Sensor
D3	3	Digital I/O (Output)	Relay_Electric_Lock
D5	5	Digital I/O (Input)	Push Button
D6	6	Digital I/O (Output)	Relay_Light_Bulb
D7	7	Digital I/O (Output)	Buzzer
D8	8	Digital I/O (Output)	LED_Warning
D9	9	Digital I/O (Input)	DHT22 Sensor Data Pin
D10	10	Digital I/O (Output)	Relay_Motor_Fan
D12	12	Digital I/O (Input)	R503 Fingerprint Sensor Data Pin
D13	13	Digital I/O (Input)	
A4	A4	Analog I/O (Output)	I2C Model Support Communication LCD1602 - (SDA)
A5	A5	Analog I/O (Output)	I2C Model Support Communication LCD1602 - (SCL)
5V	5V	Output	Power supply for the Grove-Digital PIR Motion Sensor, Push Button, LED, 3 Relays, Buzzer, DHT22 Sensor

GND	GND	Ground	Ground for the Grove-PIR Motion Sensor, R503 Fingerprint Sensor, Push Button, LED, Buzzer, 3 Relays, DHT22 Sensor, I2C Model Support Communication LCD1602 and ESP32 Module

ESP32 WROOM		
Pin Number	**Input/Output**	**Description**
RX (<-)	Digital I/O (Input)	UART Communication with TX of Arduino UNO
TX (->)	Digital I/O (Output)	UART Communication with RX of Arduino UNO
14	Digital I/O (Output)	Relay_Fan
15	Digital I/O (Output)	LED 2
16	Digital I/O (Output)	LED 1
25	Digital I/O (Output)	Push Button 2
26	Digital I/O (Output)	Push Button 1
33	Digital I/O (Output)	Push Button 3
BLynk	Wifi Input-Output	BLynk Cloud App (IoT)
3.3V	Output	2 LEDs, Relay, 3 Push Buttons

2.3. Method of Solution

The main circuit will be installed on the wall near the door to optimize the wiring distance between every part. The sensor will be wired through the door and placed on the outside of the door. When homeowners put their assigned finger on the sensor, the sensor will send a signal to the Arduino on the circuit and activate the locker inside the door. This will leave on for 90 seconds and then lock the door again. If a thief is trying to fake a fingerprint, the counter will be activated and after 3 times wrong counts, the buzzer will be on its work.

After homeowners enter their home, the PIR sensor on the ceiling will detect the presence

of them and send a signal to activate lights in the hallway to help homeowners make through the hallways. The temperature in the house is already and will always be adjusted by the fan if the humidity sensor finds the room is not in its appropriate scale.

The locker, the lights, the buzzer, and the fan can be activated through the Blynk app on the smartphone which has already been assigned a homeowner's token, which is exclusive. Also, we installed several buttons for testing inside the house and to deactivate the locker if homeowners want to leave.

2.4. Project Timeline

In the first 3 weeks of November mostly we used it for testing and developed communication between Arduinos and every part of the project. After that, we apply every part into one and maintain its communication and also its current.
In the final stages, we adjust the wiring and build the house model which is based on our dorm's room.

No.	Task Name	Start	Finish	Duration	October			November					December	
					16th	23rd	30th	4th	14th	17th	20th	29th	3rd	7th
1	Materials procuring	16/10	30/10	3 sessions										
2	Initially circuit building	30/10	17/11	4 sessions										
3	PIR and Fingerprint Sensor programming	14/11	20/11	3 sessions										
4	ESP32 communication programming	17/11	29/11	3 sessions										
5	Wifi communication programming	20/11	29/11	2 sessions										
6	LED, Buzzer, Fan wiring and programming	29/11	3/12	2 sessions										
7	Humidity and Temperature Sensor programming	29/11	7/12	3 sessions										
8	Building room model	3/12	7/12	2 sessions										
9	Final testing	3/12	7/12	2 sessions										

For more details, access Timeline.

2.5. Division of Labor

Circuit Wiring	Le Quoc Dinh, Pham Nam Nhat
Programming	Le Quoc Dinh, Tran Hong Vu
Model Building	Pham Nam Nhat, Tran Hong Vu

2.6. Ethical Dimensions and Safety Aspects

2.6.1. Ethical Dimensions

Privacy Concerns:
The collection and storage of data for fingerprint authentication raise critical privacy concerns. Users must entrust their most unique and personal identifiers to these systems, invoking questions about data security and the potential for misuse.

Informed Consent:
Ethical best practices dictate that users should be fully informed about how their data is used, stored, and protected. Ensuring informed consent is essential to maintaining the ethical integrity of these systems.

Cultural Considerations:
Different cultures have varying attitudes towards biometric data and surveillance. Ethical discussions must encompass cultural diversity and sensitivities, ensuring that these technologies are adopted in ways that respect cultural norms.

2.6.2. Safety Aspects

Security Enhancements:
Smart door locks with fingerprint authentication undoubtedly enhance security by providing a highly reliable means of access control. The unique nature of fingerprints minimizes the risk of unauthorized entry.

Motion-Sensor-Activated Lighting:
The integration of motion-sensor-activated lighting contributes not only to security but also to safety within the home. Illuminated pathways reduce the risk of accidents and provide a sense of security during the dark hours.

Auto-Cooling Method:
The method helps keeping the temperature in appropriate scales to provide a flexible and comfortable environment.

Emergency Response:
The ability of these systems to respond to unexpected events, such as break-ins or accidents, can significantly enhance safety. This capability requires a robust design to effectively address emergency situations.

3. Conclusion:

3.1. Key Points

This project is used to provide a mini smart house model with a fingerprint locker, lightning hallway and auto-cooling system.

3.2. Advantages

This system reduces people's concerns about security and their house's environment day by day. The system is low cost so it would be affordable for everyone.

3.3. Summary