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Đồ án đa ngành

Smart House IoT
Hệ thống IoT nhà thông minh

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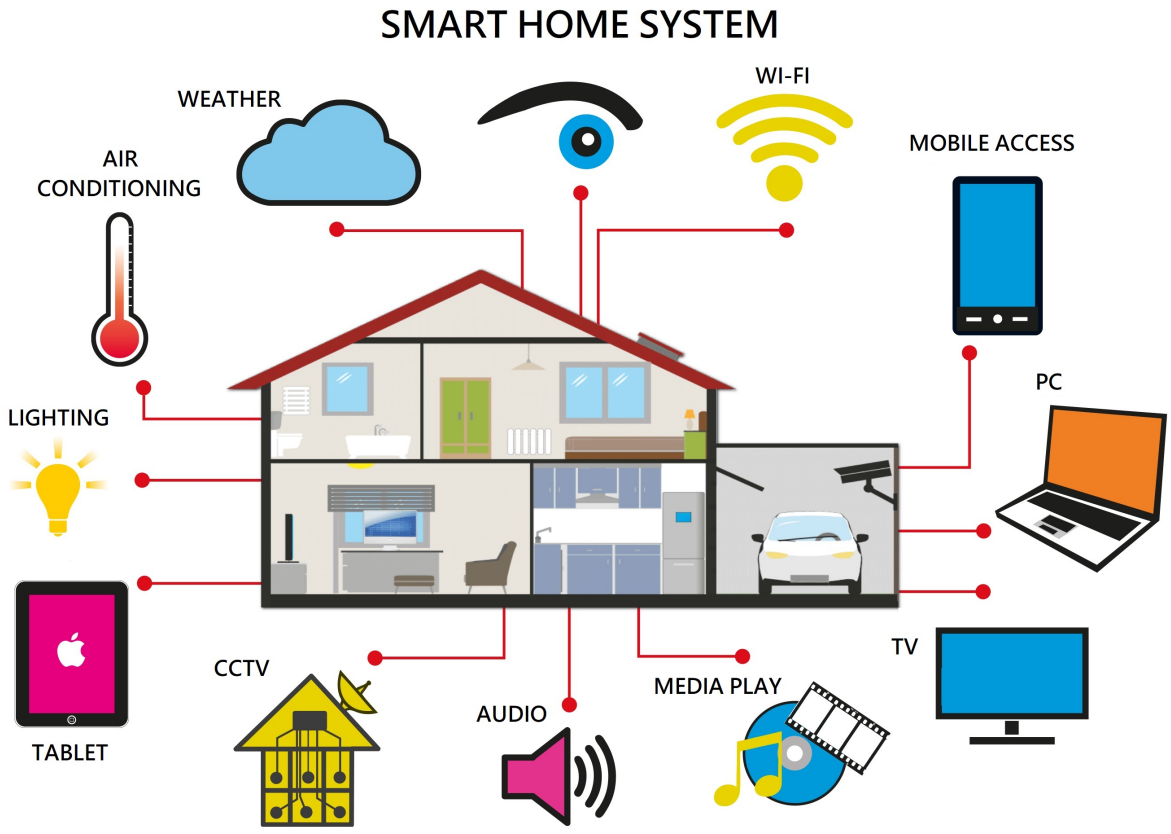
TP. Hồ Chí Minh, tháng 2/2022

Mục lục

Introduction to project

The Internet of Things (IoT) is a new revolution of the Internet that has emerged as a new paradigm of connecting objects through the Internet. The IoT is not only a network of computers, but it is a network of physical objects. Connected any devices of different types and sizes, such as lights, smartphones, AC, home systems and devices. All the connected objects communicate and share information based on protocols, make them connect together by system services. IoT enhances connectivity anytime, anyplace with anyone using any devices. Smart House systems are considered one of the most typical applications in IoT, where it is possible to control home devices to achieve a better usage in terms of cost and convenience. Smart House system is the use of devices in the house that connect via a Internet. A system consists of a number of subsystems for controlling various aspects of a house, such as a security sub-system, a lighting control sub-system, and an entertainment subsystem which allows handy access to all devices within a home either locally or remotely via the internet



Connection model of MQTT protocol

Assign work

Task name	Hưng	P.Nam	N.Nam	Toàn	Vĩ
Draw usecase	X	X	X	X	X
Define functional, Non-Functional	X	X	X	X	X
Choose devices	X	X	X	X	X
Design and implement the mobile app	X	|	|	|	|
Design and connect the hardware microbit to adafruit	|	X	|	|	|
Design and connect from client to server and document writer	|	|	X	|	|
Design UI and Web client app	|	|	|	X	|
Implement the server, establish connect two-way from adafruit to server	|	|	|	|	X
Update more devices	X	X	X	X	X
Update functional and non-functional	X	X	X	X	X
Update and complete on web	|	|	X	X	X
Update and complete on app	X	|	|	|	|
Update and complete hardware microbit	|	X	|	|	|

1 Requirement elicitation

1.1 Requirements overview

1.1.1 Context of project

Nowadays, when life is getting better and better, people's requirements also ask for the better convenience and support. Along with that is the continuous expansion of the internet network across the world to make the monitoring and control system through the internet become very important

From those actual requirements and conditions, the idea of a smart home was formed, where all human activities are supported and helped flexibly, in addition, the house can also be self-controlled management in the most intelligent way. So, what is a smart home?
The intelligence of a house is shown in 4 aspects as follows:

Automation. The house is equipped with a system of sensors such as: temperature sensor, humidity sensor, gas sensor, fire alarm sensor, obstacle sensor, light sensor ... with the ability to automatically operate according to environmental conditions. Smart homes help us monitor our electricity and water consumption better than the way we do usually.

Satisfaction. The owner of the house can control it at will or according to pre-programmed scenarios.

Security. Security monitoring system, fire alarm, gas leak alarm will automatically report the status of the house via the internet.

Control remotely. Devices such as light bulbs, air conditioners, televisions, refrigerators, ... are also connected to Internet. Users only need an internet-connected device to be able to monitor data from sensors and control devices in the home at will.

1.1.2 Smart house models currently in used

Currently North America is taking the lead in Smart home marketplace. With the era of 4 people family typed house, the smart house is provided with some functionalities: Gas alert, Breaching alert, automatic door, security camera, entertainment system,....

1.1.3 Smart house solutions

In VietNam, having a lot of manufacturers and architects who joins this market, leading are BKAV and Lumi Smarthome. With smart houses have functionalities like other countries, and have some own factor to be more comfortable in VietNam. Currently they have some advantages over other some manufacturers and architects in VietNam

1.1.4 Design Selection

Smart home is a broad topic and has many problems. Depending on the intended use of the owner to design, an important part in the smart home system is the control and monitoring system.
Previously, the smart home was only in the imagination as well as in the movies. Thanks to the continuous development of science and technology, smart home solutions are getting richer and more convenient for users. From the beginning, smart home only has remote control devices within the house to serve some human needs. Next is the automation of devices in the house with the ability to automatically adjust to the environment as well as the user
Then, with the development and spread of the internet, people came up with a solution to connect and control home appliances through the internet and add conveniences such as a safety system, computing power, etc. The energy used, ... helps the owner to control the device at a distance, not just inside the house anymore.
Security is also a top priority, because along with an internet connection, the possibility of being hacked into

the system to gain control also increases. Owners can use their own password to log into the system as well as the house through forms such as Passcode, fingerprint security, iris security... Accompanied by the ability to warn of intruders to help family Host can discover anywhere with Wifi/GPRS connection.
And recently, the trend of controlling devices by voice has also been added to the smart home building solution, making it easier to use for everyone in the house. In the future, thanks to new technological devices combined with artificial intelligence, the house can distinguish each member's voice and remember the habits of each family member.
Currently, in Vietnam, the solution to build smart homes with control and monitoring systems via the internet is still the most popular and developed because it is suitable with existing technological capabilities and economic conditions.

1.2 Detail Requirements

1.2.1 Functional Requirements

1. Simplicity Connectivity
    - IoT application can connect to a wide variety of devices - wired and wireless devices with easy instruction to connect the devices to the system and display and on the screen
2. Observing lights activities, status
    - The sensors will collect data about lights and send to server, which will send to app, web so that user can see which light is ON/OFF, managing the lighting system in house
3. Observing changes to temperature and moister
    - The sensors will collect data about the temperature and moister of the house and send to server, which will send to app, web. The user will base on the that information displayed on screen will make change to AC, open/close windows
4. Warning alert
    - The sensors will notify the user with alert message if the temperature/ moister or some conditions exceed the safe level of the house
    - if the temperature/ moister or some conditions exceed the safe level of the house, the devices will be turn off for safety purpose
5. Weekly report
    - The application will collect data and export to user as the weekly report displaying the usage of devices in house

1.2.2 Non-Functional Requirements

1. IoT aspects
    - Run 24/7 with minimal scheduled downtime and preferably no unscheduled downtime.
    - Can accommodate for multiple devices at the same time.
    - Time for getting data from server dose not exceed 3 seconds.
2. Mobile and Web aspects
    - The alarm notification will appear whenever there is an anomaly in the collected data.
    - The data is constantly updated so that users can observe the data graph anytime and adjust based on their intention.
    - The response time when control does not over 3 seconds.

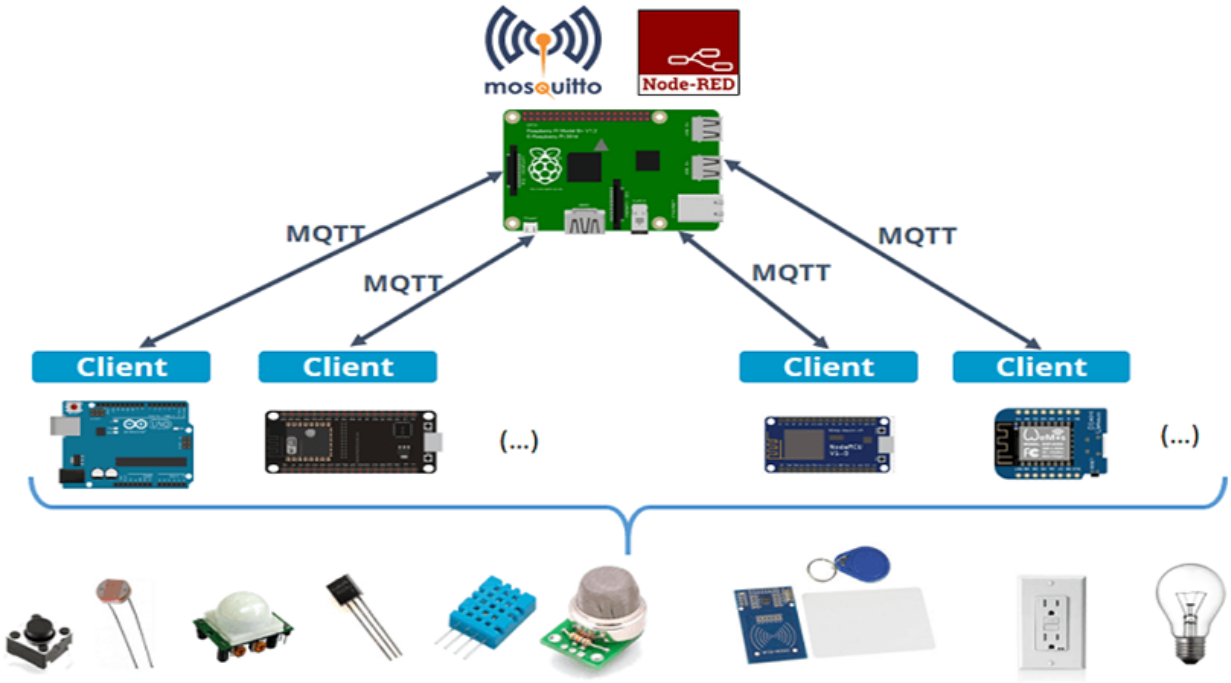
- Having friendly interface.

3. Both aspects
   - All functions can be done by pressing no more than three times.
   - The system can be controlled easily by anyone.

2 Research about Technology

2.1 MQTT protocol

2.1.1 What is MQTT?



Connection model of MQTT protocol

MQTT (Message Queuing Telemetry Transport) is a protocol for transmitting messages based on publish/subscribe model, low bandwidth usage, high reliability and ability to operate in unstable transmission condition.

2.1.2 Advantages of MQTT

- More efficiently in transmiting data.
- Increase scalability.
- Reduce network bandwidth consumption.
- Reduce update speed.
- Low cost.
- Security is guaranteed within the allowable level.
- Save development time.
- protocol publish/subscribe can collects more data than the old one.

2.2 HTTP

2.2.1 What is HTTP?

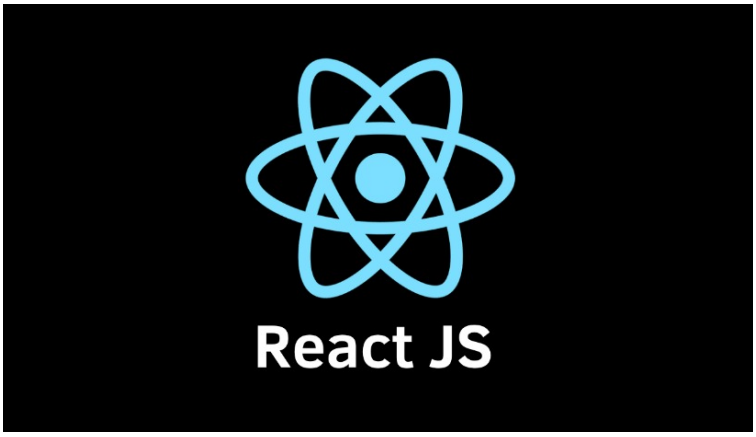
HTTP stands for Hypertext Transfer Protocol - is an application layer protocol for distributed, collaborative hypermedia information systems and a formally defined set of rules for communication between a client and a server.

2.2.2 Advantages of HTTP

- It offers lower CPU and memory usage due to less simultaneous connections.
- It enables HTTP pipelining of requests/responses.
- It offers reduced network congestion as there are fewer TCP connections.
- Handshaking is done at the initial connection establishment stage.
- It reports errors without closing the TCP connection.

2.3 ReactJS

2.3.1 What is ReactJS



Logo of ReactJS

React.js is an open-source JavaScript library that is used for building user interfaces specifically for single-page applications.
React allows developers to create large web applications that can change data, without reloading the page. The main purpose of React is to be fast, scalable, and simple. It works only on user interfaces in the application. This corresponds to the view in the MVC template. It can be used with a combination of other JavaScript libraries or frameworks, such as Angular JS in MVC.

2.3.2 Advantages of ReactJS

1. **Simplicity**
   ReactJS is just simpler to grasp right away. The component-based approach, well-defined lifecycle, and use of just plain JavaScript make React very simple to learn, build a professional web (and mobile applications), and support it. React uses a special syntax called JSX which allows you to mix HTML with JavaScript. This is not a requirement; Developer can still write in plain JavaScript but JSX is much easier to use.
2. **Easy to learn**
   Anyone with a basic previous knowledge in programming can easily understand React while Angular and Ember are referred to as 'Domain-specific Language', implying that it is difficult to learn them. To react, you just need basic knowledge of CSS and HTML.
3. **Native Approach**
   React can be used to create mobile applications (React Native). And React is a diehard fan of reusability, meaning extensive code reusability is supported. So at the same time, we can make IOS, Android and Web applications.
4. **Data Binding**
   React uses one-way data binding and an application architecture called Flux controls the flow of data to components through one control point – the dispatcher. It's easier to debug self-contained components of large ReactJS apps.
5. **Performance**
   React does not offer any concept of a built-in container for dependency. You can use Browserify, Require JS, EcmaScript 6 modules which we can use via Babel, ReactJS-di to inject dependencies automatically.
6. **Testability**
   ReactJS applications are super easy to test. React views can be treated as functions of the state, so we can manipulate with the state we pass to the ReactJS view and take a look at the output and triggered actions, events, functions, etc.

2.4 NodeJS

2.4.1 What is NodeJS

Logo of NodeJS

Node.js is a software system designed for writing scalable internet applications, especially. The program is written in JavaScript, using event-driven, asynchronous input/output techniques to minimize overhead and maximize scalability. Node.js includes Google's V8 JavaScript engine, libUV, and several other libraries. Node.js has been created by Ryan Dahl since 2009, and developed under the umbrella of Joyent.

2.4.2 Advantages of NodeJS

1. **Easy to learn**
   Be likely to ReactJS, NodeJS is also an easy programming language to learn. Once you have mastered JavaScript and Object-Oriented Programming basics. It's enough to start.

2. **Keeping things simple**
   Applications written in Node.js require fewer files and less code compared to those with different languages for front-end and back-end. You can also reuse and share the code between the front-end and back-end parts of your application. One code, one deployment, everything in one place.

3. **Faster time-to-market**
   Node.js is particularly helpful in making the time-to-market cycle shorter thanks to **massively reduce the application development time** and **get immediate feedback**

4. **Scalability**
   Node's scalability is achieved by the load balancing and the capability to handle a huge number of concurrent connections.

5. **Battle-tested old hand**
   the number of companies using Node.js for their products has increased dramatically, and the giants like PayPal, Netflix and eBay have joined the hype. Surely, Node.js is a mature and well-tested tool, and it is not going to be neglected or abandoned any time soon.

3 Devices

3.1 DHT11

- **Application:** In our project of Smart Home, this sensor can be used for improving the quality of life. It measures temperature also atmospheric humidity and send to IoT server for displaying on an LCD screen for observing. So that users can adjust base on their intention.
- **Input:** The temperature and atmospheric humidity from surroundings of the house.
- **Output:** The value after measuring. The form of data is:

  XX-YY

  Which XX and YY is temperature and atmospheric humidity respectively.

3.2 Single push button

- **Application:** In our smart home, one button is connect to a 2-color single LED - in this case is bedroom light and used to manual control that.
- **Input:** IoT application can connect to a wide variety of devices - wired and wireless devices with easy instruction to connect the devices to the system and display and on the screen
- **Output:** The output data is only 0 or 1
- which 0 is button pressed and 1 is do not press

3.3 Light sensor

- **Application:** A fairly familiar application in the smart home system is automatic light control, and light sensor can help us very well in that. In this case is bathroom light. When someone enters and cover the sensor, the light will turn on and vice versa.
- **Input:** Light level - the sensor is placed outside, in exposure to the surrounding environment settings.
- **Output:** This sensor is analog mode, and the output is a number in the range of 0 to 1023 representing the light intensity which is processed by the controller to turn on/off the bathroom light.

3.4 Gas sensor

- **Application:** A gas sensor is installed to capture the value of gas concentration and can connect to the alert system for warning when the threshold value is reached.
- **Input:** Gas level - the sensor is placed in kitchen.
- **Output:** This sensor is analog mode, and the output is a number representing the concentration of gas.

3.5 A 2-color single LED

- **Application:** In this system, we use two LED to represent for bathroom light and bedroom light
- **Input:**

  bathroom light: the value of light level measuring by the Light sensor. ON is 54 and OFF is 46

  bedroom light: the signal by press the Single push button. ON is 55 and OFF is 45.

- **Output:** None, just emits the red light for bedroom and the green one for bathroom.

3.6 LCD I2C

- **Application:** LCD is very useful for observing in application of smart home. In our project, it is connected to the DHT11 in order to displaying the temperature and atmospheric humidity.
- **Input:** The value of temperature and atmospheric humidity measuring by DHT11 converted to string.
- **Output:** The form of data displayed on screen:

  Nhiệt độ: XX

  Độ ẩm: YY

  Which XX and YY is temperature and atmospheric humidity respectively.

3.7 Buzzer

- **Application:** An alert sound system is indispensable in the smart home model. In our project, buzzer is installed and connect to Gas sensor to sound warning when the gas level is high.
- **Input:** The value of gas measured by the gas sensor and a number in the range of 0 to 1023 represents for the sound intensity of this device.
- **Output:** None, just create sound based on the input of sound intensity.

3.8 Traffic light

- **Application:** In this project, the traffic light is used quite different from its usual. Three states of light represent for three safety of levels: safe, quite dangerous, very dangerous. So that users can avoid unwanted incidents.
- **Input:** The value of gas measured by the gas sensor
- **Output:** It display three single LEDs as the traffic light with 2-pin control signal corresponding to 3 different states

  X = 00: Off - None

  X = 01: Green - Safe

  X = 10: Yellow - Quite dangerous

  X = 11: Red - Very dangerous

3.9 Expansion circuit board

- The backbone for Microbit and other sensors.

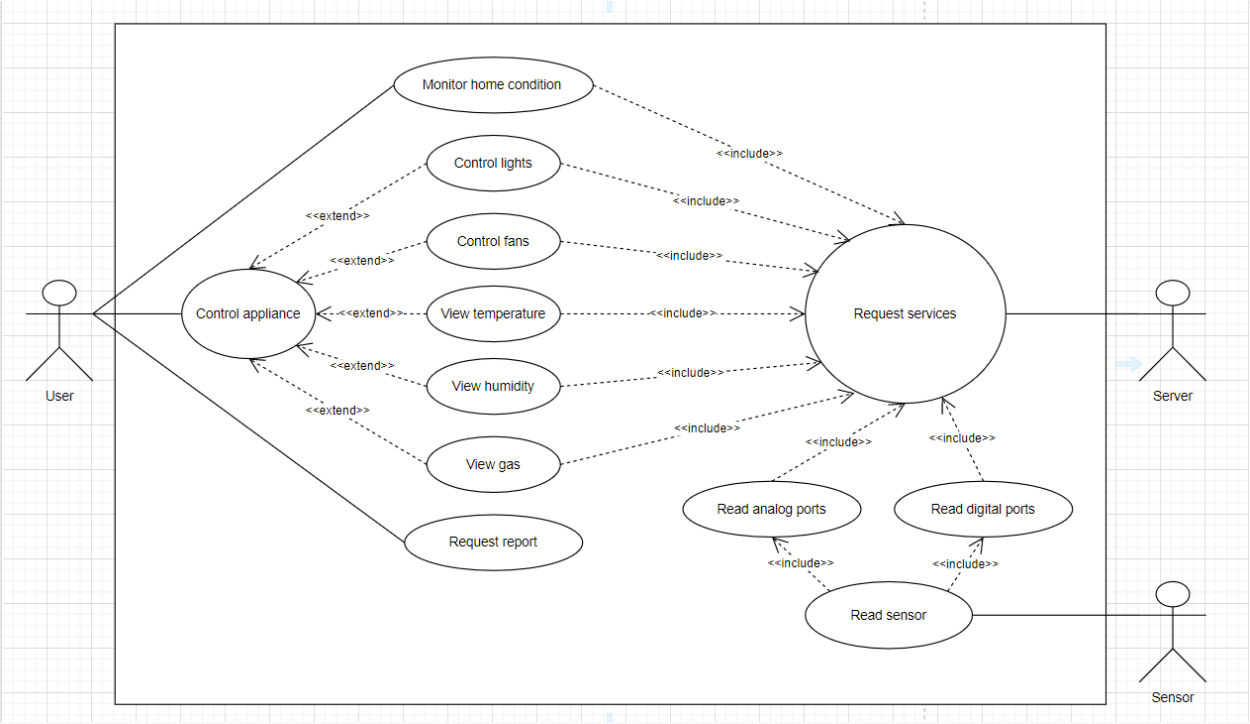
3.10 Microbit

- The hub for all sensors. It receives sensor readings through the expansion circuit board and perform preliminary processing (such as unit conversion, threshold and the like).
- Pre-processed data are then sent to the server for logging and broadcasting to all smartphones currently connected to it.

4 System analysis and design

4.1 Usecase

4.1.1 Use case overview



4.1.2 Monitor home condition

Use case name	Monitor home condition
Actor	User
Description	User can see temperature, humidity air, gas warning, number of devices, rooms in the house on dashboard
Preconditions	User has been able to connect to the app or web for his home
Normal flow	1. Open app/web 2. In the main user interface, select the room you want to see 3. Rooms is displayed as "Living room", "Bathroom", "Bedroom", "Kitchen" 4. The temperature of the house is displayed as “Avg House Temp: XX°C” 5. Air humidity is displayed as “Humidity House: XX %” 6. Gas is displayed as "Avg House Gas: XXX ppm" 7. Warning is displayed as "Gas warning", "Alarm Warning" 8. Total number of devices in house and which is on/off
Exceptions	Users who have not been granted permission to manage the house will display "No data".
Alternative flows	No

4.1.3 Control lights

Use case name	Control lights
Actor	User
Description	User controls the lights on and off
Preconditions	User in on the homepage
Normal flow	1. The system shows the list of devices of the house 2. User selects the light 3. User clicks on the light status bar to turn on/off
Exceptions	No
Alternative flows	Alternative 1 in step 1: 1. User selects a room 2. The system switches to the list of devices of that room 3. User selects the light 4. User clicks on the light status bar to turn on/off

4.1.4 Control fans

Use case name	Control fans
Actor	User
Description	User controls the speed of fan
Preconditions	User in on the homepage
Normal flow	1. The system shows the list of devices of the house 2. User selects the fan 3. User adjust the speed of fan on the control stick
Exceptions	No
Alternative flows	Alternative 1 in step 1: 1. User selects a room 2. The system switches to the list of devices of that room 3. User selects the fan 4. User clicks on the fan status bar to turn on/off

4.1.5 View temperature

Use case name	View temperature
Actor	User
Description	User views the average temperature of the house
Preconditions	User in on the homepage
Normal flow	1. On the homepage user can see the average temperature is displayed as "Avg House Temp" 2. User can view the house temperature graph for 24 hours by clicks on "Temperature" on the sidebar
Exceptions	No
Alternative flows	No

4.1.6 View humidity

Use case name	View humidity
Actor	User
Description	User views the humidity of the house
Preconditions	User in on the homepage
Normal flow	1. On the homepage user can see the humidity is displayed as "Humidity House" 2. User can view the house humidity graph for 24 hours by clicks on "Humidity" on the sidebar
Exceptions	No
Alternative flows	No

4.1.7 View gas

Use case name	View gas
Actor	User
Description	User views the gas indicator in the house
Preconditions	User in on the homepage
Normal flow	1. On the homepage user can see the gas warning is displayed as "Gas Warning" 2. The gas warning has three colors (green, yellow, red) with gas indicator from 0 - 500 3. User can see the details of gas indicator by clicks on "Gas" on the sidebar
Exceptions	No
Alternative flows	No

4.1.8 Request report

Use case name	Request report
Actor	User
Description	User view the details of the change temperature, humidity and gas indicator for 24 hours
Preconditions	User in on the homepage
Normal flow	1. User clicks on "Temperature", "Humidity", "Gas" on the sidebar to see the details 2. The system shows the details by the graph within 24 hours for temperature, humidity and by statistics for gas
Exceptions	No
Alternative flows	No

4.1.9 Request services

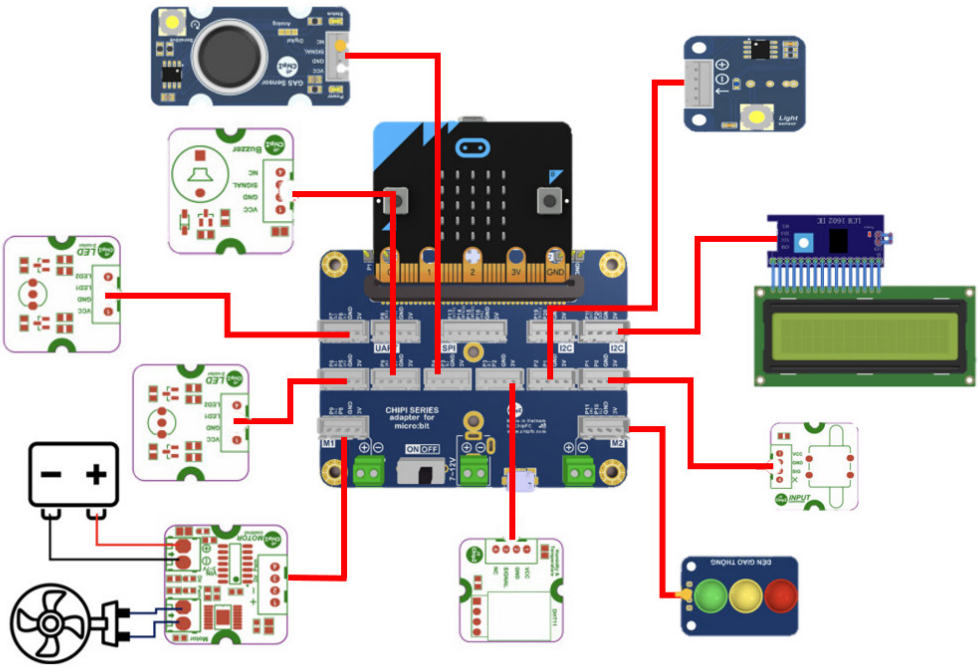
Use case name	Request services
Actor	Server
Description	Server updates changes in database when user changes on dashboard
Preconditions	User changes something on dashboard
Normal flow	1. User selects lights or fans to turn on/off 2. System get data and update into database 3. Status of the light or the fan in database will change following to the server
Exceptions	No
Alternative flows	No

4.1.10 Read sensor

Use case name	Read sensor
Actor	Sensor
Description	Sensor update the data of the temperature, the humidity or the gas when it changes
Preconditions	Sensor detect the change
Normal flow	1. Sensor detect the change 2. Update the data to the server. Each update about five minutes 3. Server saves the data and transmits it to the dashboard
Exceptions	No
Alternative flows	No

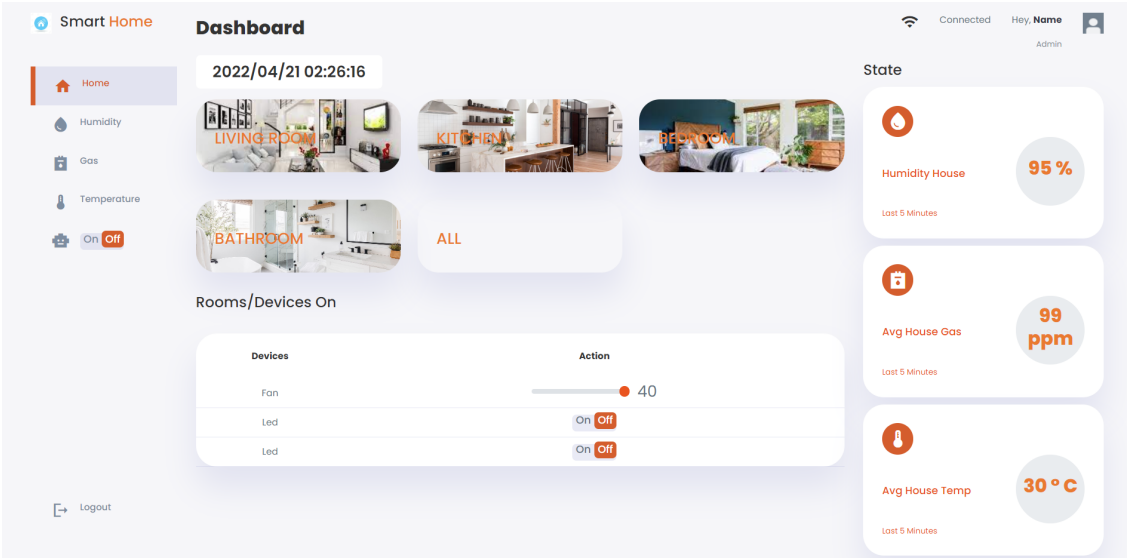
4.2 Interface

4.2.1 Circuit Interface

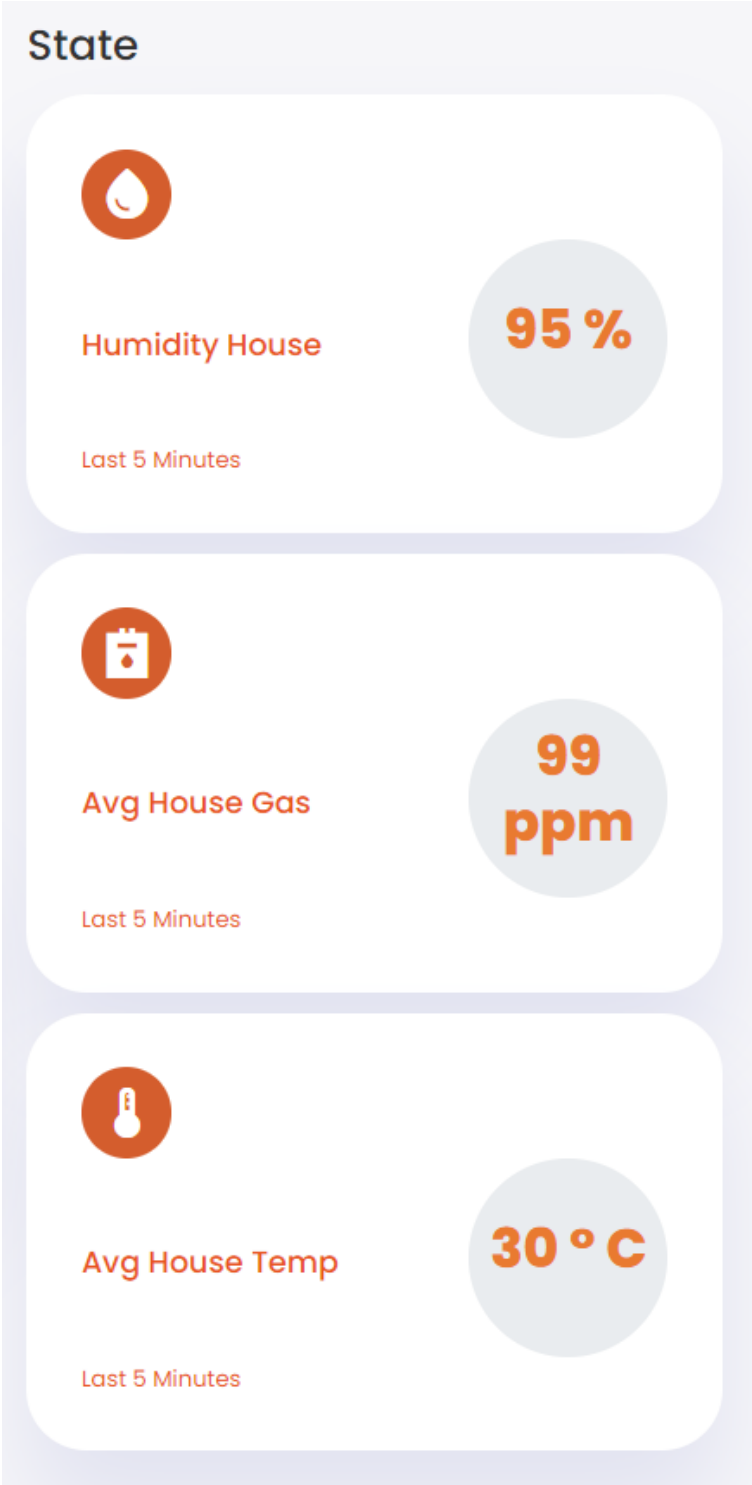


Circuit interface of our system using for Smart Home model

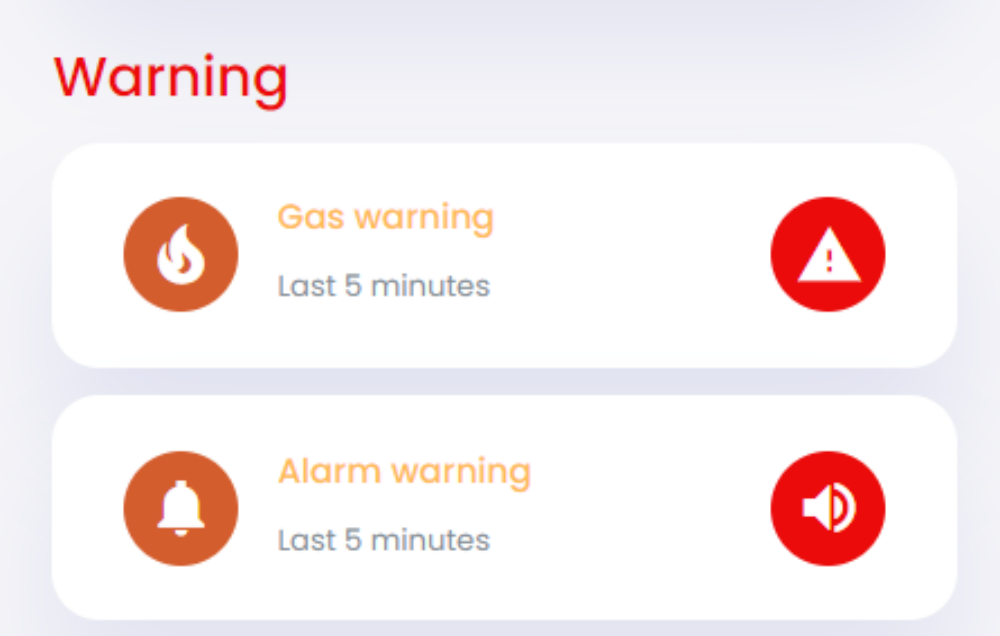
4.2.2 Home Screen



Display of Home screen

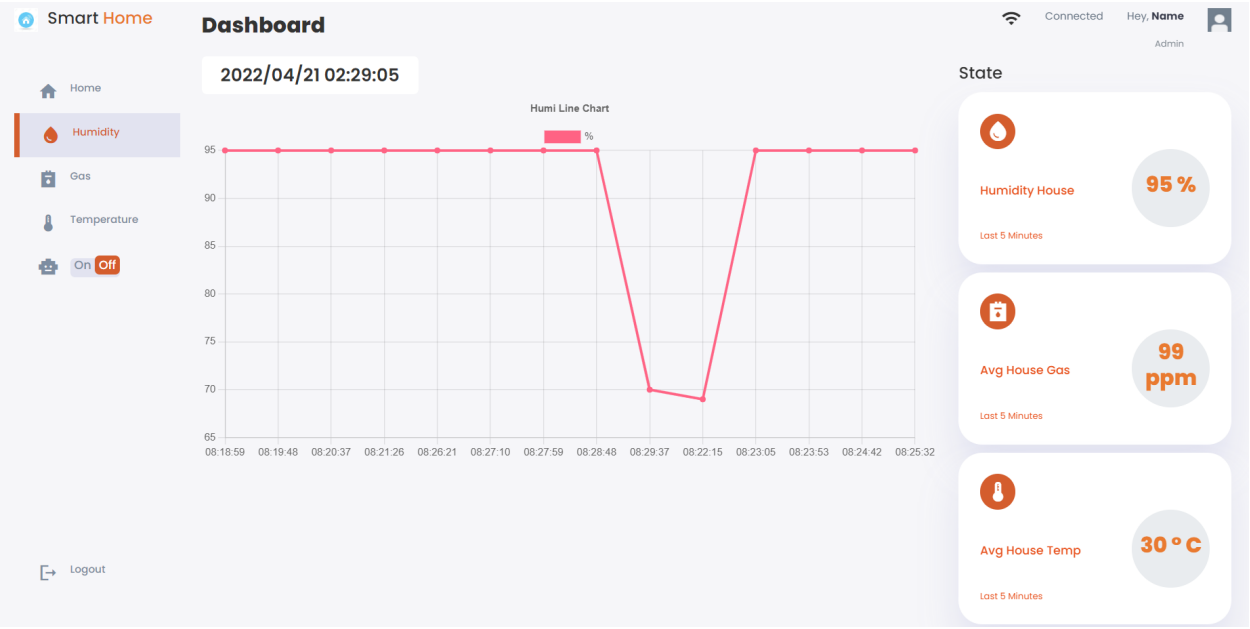


Display of State view of sensor



Display of Warning view

4.2.3 Data chart Screen

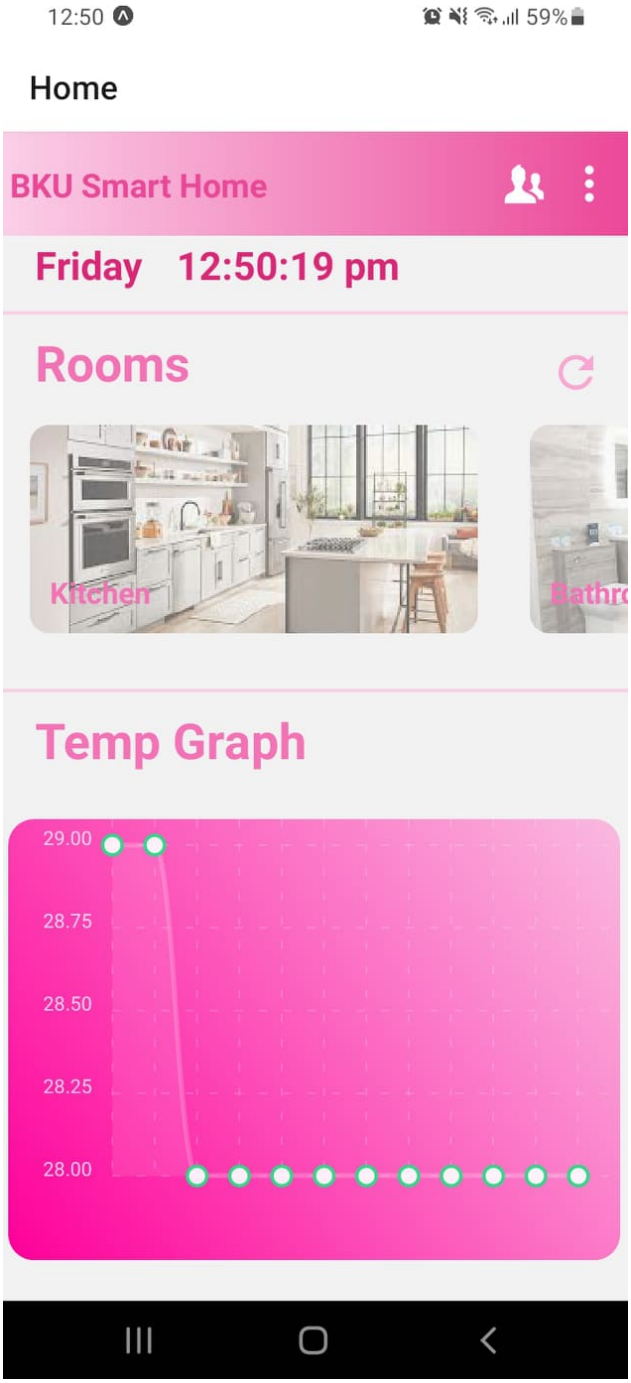


View of atmospheric humidity collected by DHT11

View of gas concentration collected by Gas sensor

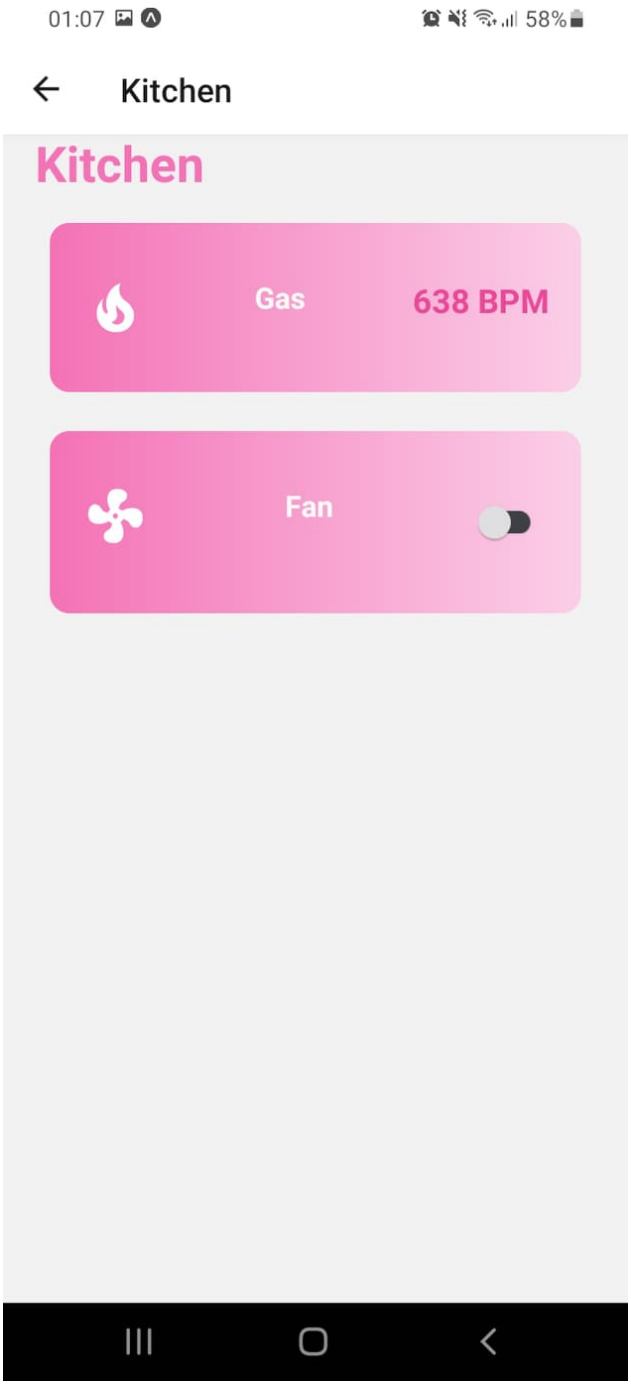
View of temperature collected by DHT11

4.2.4 App Screen



View of app's homescreen

View of room's screen



View of room's screnn

4.3 Database

We are using MongoDB which is the NOSQL database, we divide the database into 3 models which are: Device, Room, Type

```
const RoomSchema = new Schema({
  room_id: {
    type: String,
  },
  key: {
    type: String,
  },
  name: {
    type: String,
  },
  image: {
    type: String,
  },
  description: {
    type: String,
  },
  // Array of devices
  devices: [
    {
      type: Schema.Types.ObjectId,
      ref: 'devices',
    },
  ],
});
```

Room Model

```
const TypeSchema = new Schema({
  name: {
    type: String,
  },
  // Array of devices
  devices: [
    {
      type: Schema.Types.ObjectId
      ref: 'devices',
    },
  ],
});
```

Type Model

```
const DeviceSchema = new Schema(
  {
    device_id: {
      type: String,
    },
    key: {
      type: String,
    },
    name: {
      type: String,
    },
    description: {
      type: String,
    },
    data: [
      {
        data_id: {
          type: String,
        },
        value: {
          type: String,
        },
        created_at: {
          type: Date,
        },
      },
    ],
  },
```

Device Model

4.4 Trợ lý ảo - Virtual Assistant

4.4.1 Function:

In this project, we are using the virtual assistant to control devices in home through the voice. some features we have already integrated to the voice control:

- Using the virtual assistant to control status On/Off of specific light
- Using the virtual assistant to display the data of temperature/ gas/ humidity
- Using the virtual assistant to control fan with some fixed features: fast, medium, slow. We can require virtual assistant to turn on mode that we expect either turn off the fan

4.4.2 Implementation:

The way to implement the virtual assistant in this project is:

- Firstly, we use speech_recognition library to convert human voice into text thank to google's api.
- Next, gtts library is used to help us about replying to user's requests.
- Finally, our team use multithreaded programming in order to efficiently parallel process two threads: gateway and virtual assistant to reduce delay time and avoid conflicting.

5 Total rating

Thành viên	Mức độ hoàn thành
Trịnh Duy Hưng	100%
Nguyễn Phương Nam	100%
Vũ Nhật Nam	100%
Nguyễn Phước Toàn	100%
Quang Chấn Vĩ	100%

6 Link Github

Link Github : https://github.com/HUNG-rushb/Multidisciplinary-Project-BKU-2022