# Power Management System of Smart Multi-Tab Based on Iot

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***Abstract:*** ***It has recently become necessary to change the existing products to products with IoT (Internet of Things) functions, thus giving the weakness that it is difficult to utilize IoT products in terms of price burdens. Accordingly, this study aims at proposing a method for convenient, economical and safe IoT lifestyles to consumers. Arduino was utilized on existing multi-outlet power straps and it was designed to control power on/off of devices plugged into the power strip and to react to fires from the power strips. Such smart multi-outlet power strap has the advantage that it can turn existing devices to IoT devices at relatively cheap costs. Through this, it was designed and implemented for consumers to use IoT product functions conveniently and easily.***

***Index Terms:*** ***About four key words or phrases in alphabetical order, separated by commas.***

## I. INTRODUCTION

With the recent advent of the fourth industrial revolution, IoT (Internet of Things) has been receiving a huge attention. However, while a long time has passed since various IoT products such as IoT apartments were introduced through mass media, there is an issue that IoT products are still rarely used. Over 9 out of 10 Korean consumers are aware of IoT products/technologies and stated that IoT will affect human lifestyles in various aspects [1,2]. However, only 29% of consumers purchased IoT products and non-purchasers said that they did not purchase IoT products because they do not need such products (43%) and the products are expensive (39.4%). In addition, most of the respondents (82.5%) answered that they have an intent to purchase IoT products in future [3].

However, in the case of existing IoT services, the only available options are to purchase products with IoT functions or live in apartments that have applied IoT infrastructure. Such methods have the weakness that it requires high expenses. Therefore, a method to cheaply and easily access IoT is necessary, so the smart IoT multi-outlet power strap adopted a control method needed for users [4].

According to the Gyeonggi Northern Fire and Disaster Headquarters' 2017 Q3 fire statistics, the most frequent causes of fire was electric factor (36.2%), followed by negligence (29.8%). Among them, the major cause of electric fires is ignition from short circuits and over currents, and electric and electronic devices accounted for more than a third of the initial item catching fire [5]. In order to prevent fires from such over currents, a temperature sensor was attached inside the smart multi-outlet power strap to prepare for fires. According to investigations, annual consumption of standby power is 4.6 TWh, and this accounts for 1.67% of domestic annual power consumption. Therefore, a standby power warning label was installed in the application to turn off standby power of home appliances that were not used at certain timeframes [6, 7, 8].

## II. RELATED WORKS

### *A. IoT (Internet of Things)*

IoT is defined as "Service-based facilities to provide progressive services by connecting various things of the real world and virtual world through information communication technologies." It is a concept in which computing devices for configuring a ubiquitous space are embedded in environment and things to make the environment and things smart and expand the concept of M2M (Machine to Machine), which enables the communication between people and things and between things, to internet for the interaction of all information in real and virtual words [9].

### *B. Arduino*

As a tool to create interactive objects and digital devices that can detect and control the physical world, it refers to an open-source computing platform and software development environment based on a microcontroller board. There are various boards depending on the use and it offers a library with various development tools and functions. Furthermore, the circuit is disclosed as open-source, making it easy to produce and modify the board [10].

### C. *Relay* Circuit

Relay refers to "devices that control the opening and closing of other electric circuits by identifying electrical input or its size and format in response to a preset electric quantity" [11]. Relays possess the function to control, detect, remember and signal reversing action for multiple circuits simultaneously, and it has separate input/output, making it cheap and reducing the risks of damage during accidents, while having the advantage of a stable power supply.

**Revised Manuscript Received on March 02, 2019.**

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*D. Wi Fi*

Module ESP8266 can connect to WiFinetworks. It can easily connect TCP/IP and costs only three dollars. Furthermore, SDK, which can directly program ESP8266 was launched for simple programming without having a separate external device. It has low power consumption and a small size of approximately 5 cm, making it suitable for configuring IoT [11].

*E. Server*

A web server is designed in a dispersed client server structure and a web client is a type of program that sends all kinds of requests including document information to any web servers. Web server offers the function of replying to client requests (URL) through HTML documents by activating HTTP daemon on the server. At this time, it can send texts as well as multimedia data such as sounds, videos and images according to the MIME type [12].

## III. POWER MANAGEMENT SYSTEM OF SMART MULTI-TAB

*A. System Design*

In this study, an Arduino board was used and a temperature/humidity sensor that receives environmental information surrounding the multi-outlet power strap, relay for power control of the target, spark detector to detect fires, and a server to relay communication with wireless communication (WiFi) for communication between the target and application were produced. Using such power management system of multi-outlet power strap, a system that can control power of the power strap, detect fires and safely use the power strap via smartphone was proposed. The system blueprints are as shown in Figure 1.

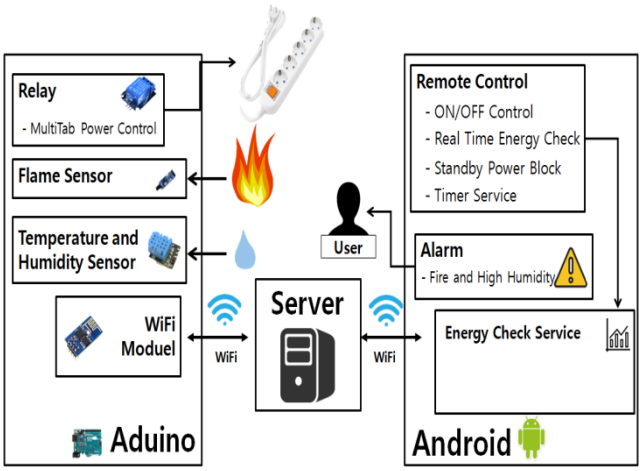


**Fig. 1System Architecture**

These blueprints contain Arduino module that utilizes a relay that controls electric currents, spark detection sensors that can detect fires in the multi-outlet power strap, and a temperature/humidity sensor that measures temperature and humidity in which multi-outlet power straps can be used, and a communication module that links with Arduino via a server using WiFi, and an application module that displays the target's information. The application control module displays the temperature and humidity values received from Arduino in the application and it controls the relay using WiFi communication and the notification functions of spark detection sensors. Through this, users can conveniently and safely use and manage multi-outlet power straps from remote locations. In case of remote control module, it is comprised of a relay that controls the ON/OFF of multi-outlet tab, temperature and humidity sensor that collects temperature and humidity information, and WiFi communication module (ESP8266) that sends information on spark detection and temperature and humidity to Android. Also, alarm module of the application enables a user to prepare for emergencies by sending emergency alarms to user when sparks are detected in multi-outlet power strap.

*B. System Implementation*

The system explained in this study was configured in Windows 10 64 bit operating system and Arduino was configured using a program calledArduino Sketch. This system is comprised of Arduino and load cell and WiFi module and an amp was also used to connect the weight sensor and Arduino UNO board for its configuration.

```
IF HV <=70 THEN
Humiditiy Value <= 70      // If humidity is less than
                              70%, execute code below
 IF data = 1
  THEN
   data = 1          //If the data value is equal to 1, run the
code below
DigitalWirte (Relay, HiGH)      // Print "HIGH" signal
                                   to digital B  pin
Serial.print("Relay ON")        // Print "Relay ON" on
the serial monitor
 ENDIF
 IF data = 2
  THEN
   data = 2          //If the data value is equal to 1, run the
code below
DigitalWirte (Relay, LOW)       // Print "LOW" signal to
digital B pin
Serial.print("Relay OFF")        // Print "Relay OFF" on
                                   the serial monitor
 ENDIF
ELSE          // If humidity is more than 70%, execute
code below
DigitalWirte (Relay, LOW)
Serial.print("Relay OFF")
```

**Fig. 2 Relay Control Flow**

In the application shown in Figure 3, multi-outlet power strap can be regulated when humidity is less than 70% and by clicking ON and OFF button of the application, a divergent number is sent through the if statement to control the power strap. The ON and OFF buttons of the application are as shown below.

The temperature and humidity information communication algorithm of the web server and Arduino is as shown in Figure 4, and the temperature and humidity information collected by Arduino after the connection between Arduino's ESP8266 modules are sent to the web server to be accumulated in the web database. The accumulated data can be checked in a separate page (php) on the web server.


**Fig.3Relay On/Off Switch**

After setting the interval of information of sensors to be brought in after connecting to the router web server using ESP8266 module, connect to the client server and record the information of sensors in php file.

```
Void function setup()
Serial.begin (115200)
 IF Ethernet.begin(mac) ← 0 THEN
 Print("Fail Failed to configure Ethernet using DHCP")
 delay ← (100000)          // Give the sensor some time to start
 data ← " "
END setup
Void function loop()
currenMillis ← millis()
 IF currentMillis - previsousMillis< interval
  THEN // Read data only once per interval
previousMills = previousMillis
   h ← readHumidity
   t ← readTemperature
 ENDIF
  IF client.connect("192.168.58.1",80)
   THEN
client.print ← ("Post /new.php. HTTP/1.1")          // Client connection file
client.print ← ("Host : 192.168.58.1")          // Server address here
client.print ← ("Content-Type: application /x-www-form-urlen-
                coded")
client.print ← ("Content-Length : ")
client.print ← (data.length)
client.print ← (data)
 ENDIF
 IF client.connected
  THEN
client.stop // Disconnect server
 ENDIF
END loop
```

**Fig. 4Arduino Web-Server Connection Flow**

*C. Implementation Results*

The system was operated in Arduino Uno, Android 4.4.2 (Kit Kat) and the results of system implementation are as shown in Figures 5, 6 and 7. Figure 5 is the main screen of the application and it shows the status of Arduino when the temperature and humidity sensor is operating.

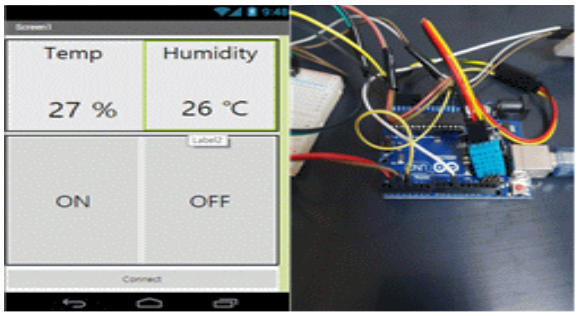


**Fig. 5 System Implementation Results 1**

Figure 6 shows the humidity and temperature obtained from the temperature and humidity sensor with % and ℃ on the upper part of the application and when it increases above humidity of 70% or temperature of 70℃, which are the safety standards for multi-outlet power straps, it sends a block current signal automatically to relay to prevent fires.

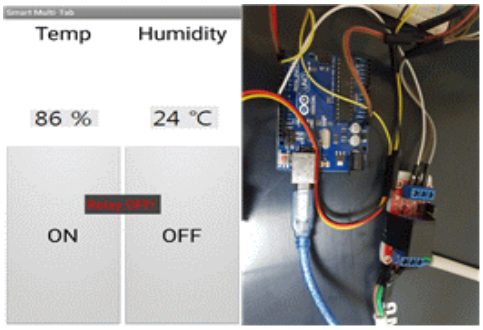


**Fig 6System Implementation Results 2**

Figure 7 shows that when flame detection sensor detects fire information, it sends a push notification and alarm to user's application so that the user will be aware of fire in multi-outlet power strap.

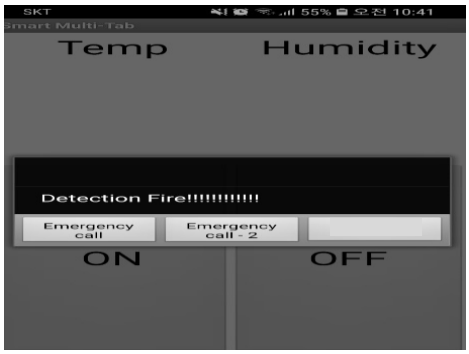


**Fig. 7System Implementation Results 3**

## IV. PERFORMANCE EVALUATION AND RESULT

The performance evaluation results of the fire detection sensor are as shown in Figure 8. The fire evaluation environment assesses the level of accuracy for detecting fires per distance from the fire detection sensor. The results in Figure 8 shows the difference between application module distance measurement and actual distance. It was measured 80 times for each distance and shows the mean values.

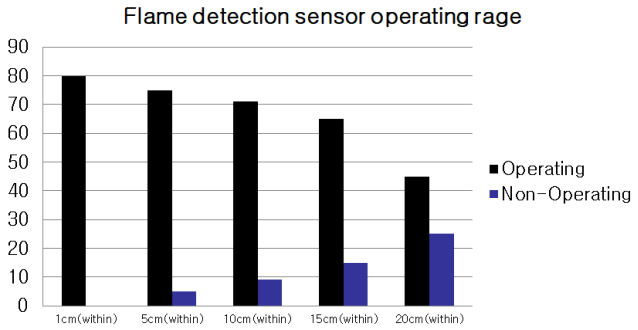


**Fig. 8Flame Detection Sensor Evaluation Result**

In Figure 8, it shows that as detection of fires are measured by the existence of sparks, it measures sparks relatively accurately at close ranges, but for targets 15 cm - 20 cm away, it had a margin of error in excess of 20%-45%. Fires are detected by detecting sparks as shown in Figure 9 above, but this has a limitation that it can detect within a distance of 20 cm. Therefore, in order to address such limitations, a temperature and humidity sensor is used to prevent and respond to fires by blocking currents in the multi-outlet power strap when the temperature exceeds a certain value using the surrounding temperature to prevent fires resulting from heat.

Figure 9 compares the effects when standby power is blocked using an electric current sensor. It compared the amount of standby power used when connecting a home PC to a multi-outlet power strap. It was measured at PC specifications of 500W power, I5 - 8400 CPU, GeForce GTX 1060 3GB GPU. The average standby power of the PC was 17.8 W, resulting in approximately 2,400 won of electricity fees, but when standby power was turned off, it was about 1.1 W, which would be equivalent to about 150 won for electricity costs. Therefore, it is expected that it can reduce electricity fees by more than 2,250 won.

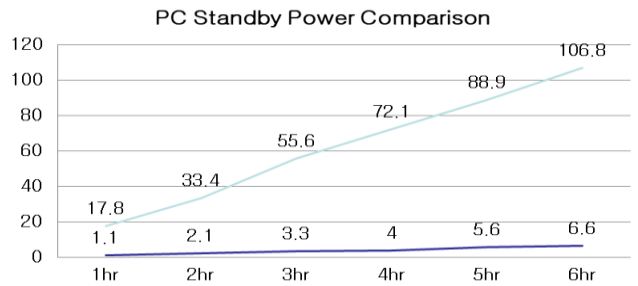


**Fig. 9Standby Power Cut-off Evaluation Result**

## V. CONCLUSION

This study designed and implemented a power management system of smart multi-outlet power strap using Arduino board, WiFi communication module, web server, relay, temperature and humidity sensor, and spark detection sensor. Using a multi-outlet power strap with Arduino instead of typical multi-outlet power straps, it is expected that it would be possible to manage power conveniently using application even at distances away from the power strap, while being able to take a prompt action in case of fires in the multi-outlet power straps for safe use and reduced damage from fires.

In future, a system will be built that can block the electric current of multi-outlet power strap together with sending emergency push notifications in the event that allowed rated power is exceeded, while automatically cooperating with relevant institutes in case of fire.

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