Smart AirBox: Optimizing Library Sustainability with an IoT-Driven Efficiency-Based Temperature and Humidity Monitoring Application in the Engineering Library, Universiti Sains Malaysia

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ABSTRACT

The project aims to monitor temperature and humidity in library material locations through a mobile device monitoring application systematically and to sustain the longevity of library collections in the Engineering Library, Universiti Sains Malaysia (USM). The Smart AirBox device and its application is one of efforts towards pertaining sustainability effort in maintaining value added service in the library. The paper also discusses the calculation and efficacy of Business Process Automation resulting from the application of Smart AirBox innovation. The platform enables librarians to create and manage IoT devices, applications, and services in the process of monitoring and reporting the collection's status quickly and easily. The system developed successfully monitor temperature and humidity levels in different locations using reliable and user-friendly equipment with wireless connectivity and a mobile phone application managing multiple sensors on a single platform replacing traditional manual systems. In addition, the system significantly helps to align USM Library policies and standards while providing significant energy and time savings. Future improvements need to include using upgraded WIFI sensors, creating a "smart scene" for more creative signals, and extending sensor installation to other library branches for standardization. This project's contribution is to provide a solution that replaces the manual process of monitoring library materials with a reliable, user-friendly, equipment with wireless connectivity that provides fast information and fast problem-solving.

Keywords: Internet of Things (IoT), Temperature and Humidity, Industrial Revolution 4.0, Library Collections, Business Process Automation (BPA)

INTRODUCTION

In addressing the challenges of the era of technology and digitalization in Malaysia, the Engineering Library at Universiti Sains Malaysia harnessing technological advancements and its potential of Industrial Revolution 4.0. At the Engineering Library, Universiti Sains Malaysia (USM), Engineering Campus, Nibong Tebal, Penang, two innovations have been developed: temperature and humidity electronic devices and the integration of a monitoring mobile application system. This project intends to make the manual process of monitoring the temperature and humidity of items in the library more efficient by monitoring from various areas where resources such as books, media materials, maps, and so on are placed. Previously, librarians collected temperature and humidity readings using a temperature reading equipment, such as at the location of a bookshelf on the second floor of the library and record them in a logbook.

This action or activity must be repeated in a predefined period to ensure that the temperature and humidity do not exceed the authorized limits to ensure that the material is due to illnesses such as book fungus and has gone through the process of deterioration. This situation requires early detection to report it to the library management for control and prevention measures such as vacuuming and spraying. Manual methods like this are inefficient in terms of time because librarians need to attend each location that houses the temperature reading device to obtain a sample of monitoring data as well as detection of the permitted temperature and humidity levels and then need to make an analysis from the data. Likewise, library items that are not consistently checked for temperature and humidity are at risk since the material's shelf life is reduced and deteriorates. The Internet of Things (IoT) technology aids in the solution of this problem, as the system that will be developed constantly monitors the temperature and humidity conditions, and the data received is the most recent reading recorded by the sensors, which is then stored in the data center of the Communication Knowledge Centre and Technology (PPKT), Universiti Sains Malaysia (USM). This situation enables analysis and monitoring to occur promptly and at any time.

BACKGROUND

This project must be implemented because there is currently no method or facility in place to monitor the temperature and humidity of the library's holdings from multiple places online. Previously, temperature and humidity monitoring were done manually, with librarians visiting each site one by one and reading the temperature and humidity from the temperature reading device installed there on a regular basis. Furthermore, the library's compilation of monthly monitoring reports to fulfil MS ISO 9001:2015 record and auditing criteria reduces the efficiency of the existing manual procedure. In addition to the manual technique, systematic early warning warnings against temperature and humidity levels that are permitted for the purpose of preventing or decreasing harm to library materials are also not practical. Another factor is that manual reading is no longer useful because earlier data storage (History Log) is often incomplete or non-existent.

OBJECTIVES

This innovation project has three main objectives which are:

1. Monitor temperature and humidity monitoring functions online from various points across the library using open-source equipment.
2. To capture data in a systematic manner.
3. To save time, cost, and human resources by manually managing the process and activities of data collection.

IMPLEMENTATION OF THE PROJECT

A device equipped with a wireless chip and a temperature and humidity reading sensor/sensor will be installed in a site where Library resources are present, such as a bookshelf on the second floor of the Open Shelf Collection. Raw data will be transferred to the hosting server using Hypertext Transfer Protocol (HTTP) over a USM Secured Wi-Fi Channel or USM Things. The data reading results from this sensor will be processed using a machine language script to take repeated readings every five minutes and send them to the hosting server for processing and storage in a centralized database.

Data results can be displayed to users or librarians using a mobile application system. Overall, the goal of this project is to use a web application to monitor the temperature and humidity in the environment where the library resources are stored. The graphic below depicts the proposed implementation of this project. (Natalie Paskoski, n.d.)

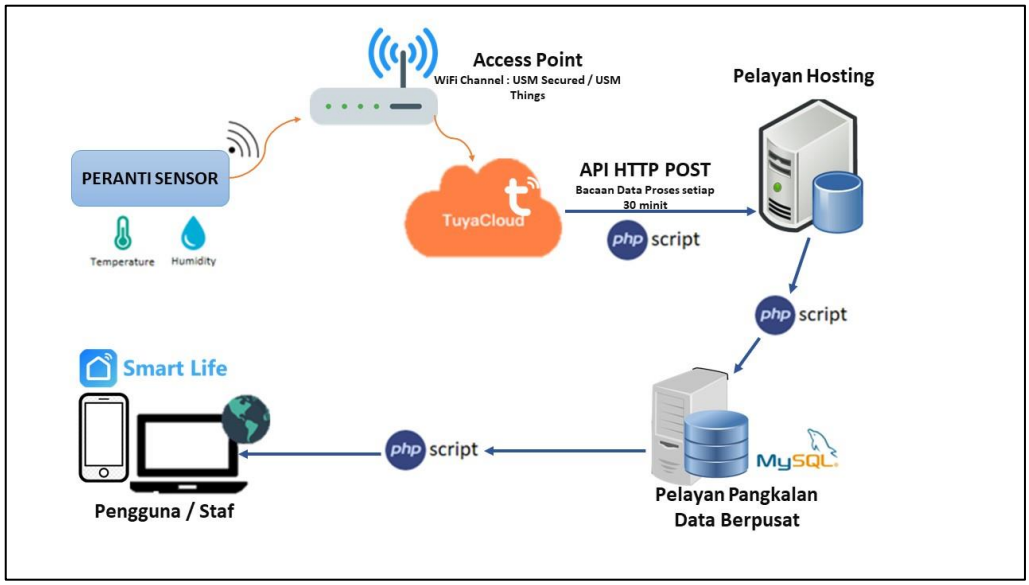


Figure 1: Overall Diagram of Operating Temperature and Humidity Monitoring System

Methodology Of Project Implementation

Business Process Automation (BPA) of an organization's operation through technology to save costs, improve productivity and efficiency and we choose as an approach is as to improve organizational efficiency by lowering effort levels and getting rid of unnecessary processes and procedures as suggested by (Sirohey & Khalid, 2012). It is assumed to enhance organizational efficiency by decreasing the level of effort and elimination of redundant processes and procedures. Thus, we chose the Business Process Automation (BPA) as the project methodology that is being used to measure the correct outcome of the project's successful completion both before and after.

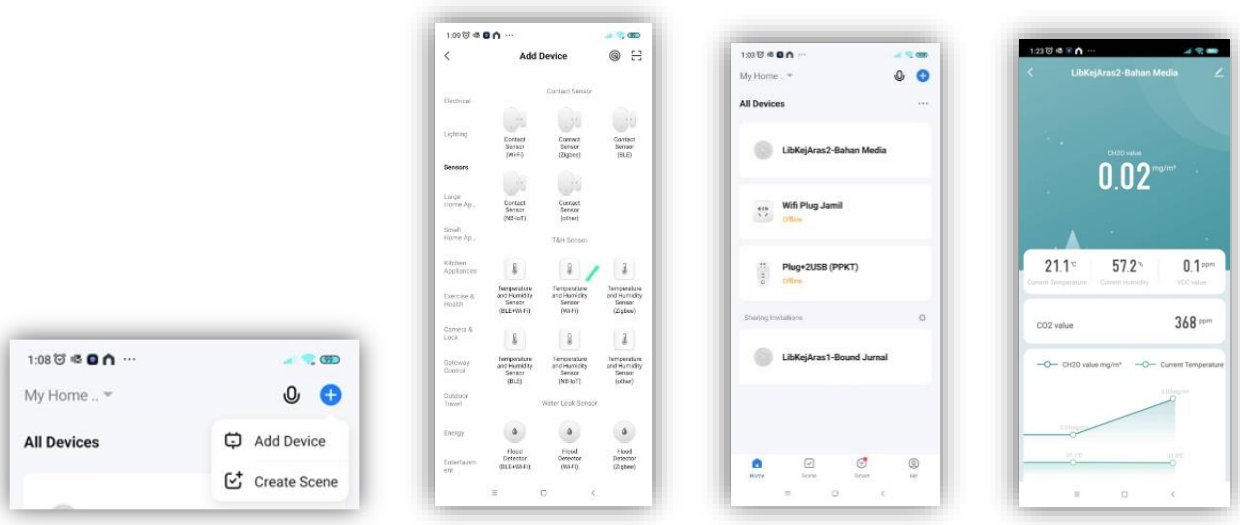
System Testing and Implementation

Tuya App Account Configuration (Smart Life)

Step 1: Install the application on an android smartphone at the following link https://play.google.com/store/apps/details?id=com.tuya.smartlife and iPhone users can download it at the link https://apps.apple .com/us/app/smart-life-smart-living/id1115101477

Step 2: After the installation, create a new account. Then, obtain the registration verification code, make a password, and log in to the appropriate application, ready to bind or connect a sensor device to the application.

Step 3: Add a new sensor by clicking on the 'Add Device' application.



Step 4: Once completed, click 'Add Device' to alter the name and so on. Added sensors can be shared with other Tuya Smart Life users.

Output Testing Plan

To test this concept, it was installed in two locations: the Media Room on the second floor and the Bound Journal Collection on the first floor. Both venues contain distinguished resources, such as media and books/printed materials, and have various temperature control standards and humidity monitoring. As a result of the test, the sensor can connect to Wi-Fi and read the data, which is then successfully entered into the built system.

Figure 2: Location of the 1st Floor of the Bound Journal Collection

Figure 3: Location of the 2nd Floor Media Room

Meanwhile, the responsible librarian's mobile phone has installed the 'Tuya Smart Life' program, as well as the system's 'id' and password, for added security.

Figure 4: Librarians Test the 'Tuya Smart Life' Mobile Application System

PROJECT IMPACTS

Before and After Project Implementation

Table 1: Business Process Automation (BPA)

Business Process Automation	Before	After
Process Step: There are several process step and procedures in handling and collecting data	5 steps	1 step
	1. Get to the location 2. Record data from the location itself 3. Transfer the record 4. Perform manual calculations 5. Create a monthly report	1. Retrieved the data from the smartphone device
Staff: The number of staff responsible in processing the task in managing and collecting the data from various location	5 staff members from Circulation Division	1 staff member from System and Archives Division
Process time	30 minutes approximately	5 minutes approximately
Cost: The estimated cost of recruiting staff	RM14,750.00	RM2,950.00
Waste	5	3
Lead Time	150 min.	5 min.

Project Impacts on Business Process Automation (BPA)

The impacts on Business Process Automation (BPA) can be shown in detail below:

Table 2: Project Impacts Before and After

CATEGORY	ACTIVITIES		EFFICIENCY LEVEL	EFFICIENCY %
	BEFORE	AFTER		
Process Step	5	1	3	80%
Staf	5	1	4	80%
Process Time (Minutes)	30	5	25	83%
Cost (RM)	14,750	2,950	11,800	80%
Waste	5	3	2	40%
Lead Time	150	5	145	97%
Process Efficiency				**86.2%**
Cost Efficiency				**80%**

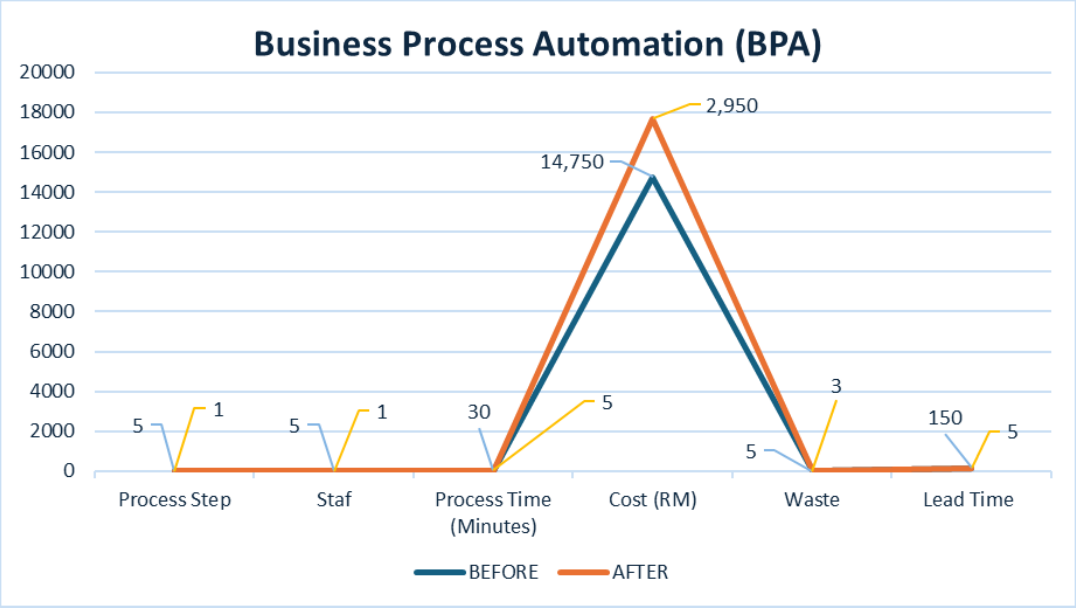


Figure 5: Project Impacts Before and After

LIMITATIONS TO THE SYSTEM

There are several challenges in executing this project, one of which is building the sensor/sensor on your own/DIY (Do It Yourself). Constraints of knowledge and skills in the field of electronics slightly hinder the development of this DIY version of the product because it requires the recognition of electronic circuit experts and electrical experts to ensure that the device that is built complies with the standards and thus guarantees the safety of its use in the future. Furthermore, there is a limit to the use of Wi-Fi in the Library building which has limited access. It causes the 'signal' that is emitted to not reach the installed sensor/sensor causing it to not work properly. Wi-Fi access should be improved by creating special channels such as 'USMThings' on devices that have support for 2.4 Ghz device connectivity. To get more information about the data in the Tuya cloud, it requires the management to subscribe and upgrade the paid API version for future reference and system development research purposes. However, the basic package used in this project is sufficient to get data from the Tuya cloud into the centralized database that has been created with this system.

FUTURE IMPROVEMENTS

A recommended upgrade is to replace the existing Wi-Fi sensor with a Wi-Fi 'Zigbee Gateway'. It allows these sensors to be easily connected to the 'Zigbee Gateway' rather than directly to the current Wi-Fi channel. This gateway has the advantage of simply needing to be configured once with the Wi-Fi network administrator, rather than having to configure each existing sensor. This means that existing sensors can be configured using only the gateway. The next step is to improve the existing system by creating ‘smart scenes' to execute other functions, such as activating gadgets that can send more creative signals, such as illuminating beacon lights based on color. For example, yellow for alert sensors and red for danger sensors. This situation can be implemented by having the librarian on duty act as a control center for monitoring the temperature and humidity levels.

CONCLUSION

The system that was established can help enhance cost efficiency and human resources in processing activities, particularly the more efficient monitoring of temperature and humidity, as manual monitoring is no longer required. A system that can be accessed online 24/7 via the Internet will assist ensure that the Engineering Library, USM's storage space and atmosphere always meet the standards and practice procedures established. A well-preserved collection can be consulted for a longer period and improve service delivery to users.

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