"Keep It Cool" Smart Bag by Internet of Thing (IoT) for Better Living with Alternative Design

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***Abstract*—Nowadays, while the manufacturing world is transformed from industry 3.0 to industry 4.0 that is a concept of digitization, IoT platform has been considered and continuously revaluated to make people feel more comfortable and safer. In this research, "*Smart Bag*" was used as the case study with IoT platform for easily adjusting the temperature inside the bag by voice and mobile application where the extra function "*Lost and Found*" was added into the "Keep it cool" bag platform to identify the location of the bag and stuff inside. The notification for announcing the defective items or failed conditions that occurred can be quickly shown on the screen of the mobile phone. With the assistance of the product design and development (PDD) concept, creating the smart bag prototype requires a shorter time where the customer's needs can be revealed and translated into engineering design. For the last phase of this research, the performance of the created prototype was presented and discussed.**

***Index Terms*—Internet of Thing (IoT), Temperature-Sensitive Product, Insulated Container, Product Design and Development (PDD), Controlling System, and Smart Bag**

I. Introduction

Over the past five years, "*Internet of Things* (IoT)" has been introduced as an extraordinary system of interrelated computing devices, e.g., mechanical and digital machines, objects, animals, or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [1]. IoT devices are created for consumer use, including connected vehicles [2], home automation or the so-called smart home [3], health-related products for supporting elderly care such as voice control [4], or sensors that monitor and remote notification for medical emergencies [5], and transportation applications as smart traffic control or parking system, electronic toll collection, and road assistance (digital variable speed-limit sign) as shown in Fig. 1 [6].

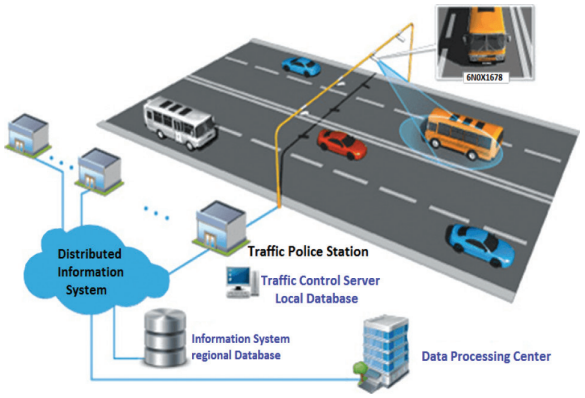

Fig. 1. Traffic management system [7]

A. Smart Home System

Fig. 2 presents the smart home system that contains many intelligent components and instruments for controlling applications such as air conditioners, fans, lamps, and all electrical home appliances. Normally, an air conditioner is turned on only when a user goes back home and he/she waits for the desired temperature that was set by him/her. Whereas, with the IoT, when a human's car is just a few minutes away, the air conditioner receives the message sent from the smart device to the cloud and then sent to the receiver at home to turn on and set the temperature value as well before the human arrive home.

The ability of the mobile/network controlling system of IoT can help the user to prevent exposure to the dangerous situation directly since the machine or device can be monitored and controlled from anywhere around the world [8]. Currently, there are many technologies and applications that can be installed and applied in smart homes; however, the direct/target customers might have no idea what they really need for their

homes, and cost for installation and maintenance are quite expensive. These have led to the situation that the customers stop to make their decision at the initial stage for intelligent living. Therefore, small smart items/devices as additional building tailor-made automation units/systems that perfectly fits to the customers' houses with affordable budget have become very popular. The concise and clear instructions or manuals that provide feasible solutions based on customer preferences (easy-to-understand and-access platform) to make the system practical, simple, and convenient to use must be created [9].

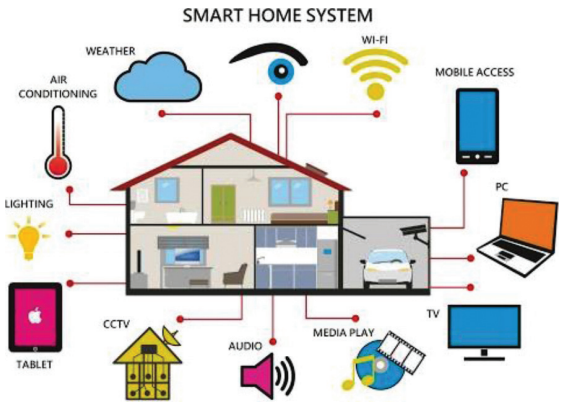

Fig. 2. Smart home system [10]

B. Smart Health IoT Connectivity

IoT in health care can improve the quality of care. The treatment management could be further improved when patients are monitored on a continuous basis. Real-time health data is available thus diseases are treated before the condition get out of hand. Remote monitoring of patients' health statistics greatly facilitated the further diagnosis. With the IoT diagnosis resulted in medication reaches every nook and corner. IoT makes better treatment because it connected health care solution and virtual infrastructure that make treatment precise and better. Enhance emergency care, the advanced automation, and analytics of IoT allow more powerful emergency support service.

Talkable medical devices remind patients to take medicines as prescribed and other necessary action to improve health. Accurate collection of healthcare data minimizes errors and make precise medication. On the other hand, pill size ingestible sensor would constantly check whether the patients are taking medications as prescribed by the doctors or not. IoT can also predict the arrival of the patients.

The most significant advantage of using IoT for the elderly is to monitor and manage health conditions. IoT wearables can track blood sugar levels to track and manage diseases like diabetes. Moreover, with the assistance of an expert panel of IoT platform, the older adults who live alone can automatically call to their relatives or the nearest hospital when they need help [11]-[13].

Before deciding to select the special gadgets or items as IoT platform for supporting convenient life, advantages, and disadvantages of IoT should be taken into considerations.

II. Research Background

Advantages and disadvantages of IoT applications have been taken into considerations and analyzed firstly for supporting the concept of "*living in a world of smart everyday object*" used in the proposed research. Before starting concept development phase, the hidden issues of IoT platform will be revealed and extracted in sequences. The benefits obtained from the existing applications will help the design engineer generate the drafted idea for creating the innovative product properly.

A. Advantages of IoT

Some advantages of IoT are described as:

1) Convenient

The best example for this case can be shown through "*online shopping websites*" where the number of products that are available in the store can be easily checked [14]. Once the customer makes decision to purchase a product presented in the website, he/she can select that item and put it into the digital basket for reserving process, and then digital payment platform is activated. Using this digital application can help to minimize the time to spend for travelling to the shop/store, and this can eliminate buying-failure situation where the desired product is not available when the customers attempt to be there for getting the items they want. Doing this is not only saves time but is convenient as well.

2) Tracking

"Thailand Post" is one of the popular tracking applications, using tracking number and locating the parcel anytime. Thailand Post is a postal service company that allows a customer to trace his/her packages. Packages sent via *Thailand Post* can be delivered in a few ways where the tracking number is included. Customers (sender/ receiver) using the tracking form can quickly check the status of the package. Moreover, if the customers would like to get updates on their package location via e-mail, they can register on the official website [15].

3) Time

"Airline Business" [16]-[17], the amount of time saved in managing booking by entering booking reference number and last name to rebook new flight, request additional services such as meal, seat or excess baggage, and update personal information such as email or phone number.

4) *Money*

For the financial aspect, using IoT can help to replace humans who are in charge of monitoring, maintaining supplies, and managing complicated tasks. Nowadays, for high-trust service and organization" as financial institutions and banks, "*Online Banking Services*" are very popular to support today's competitive society where the concept of "*Banking Anywhere Anytime*" is applied. Accessing bank account to keep track of money, fund transfer, top up, to make payment, view statement, and schedule transaction in advance up to 12 months can be easily done in seconds [18]-[21].

B. Disadvantages of IoT.

Some disadvantages of IoT are:

1) Accessibility

The concepts of IoT and the products produced by applying smart sensors or intelligent modes have been essentially used to improve the quality of life; however, with the usage of software or programming-based technology gadgets, these might bring some misunderstood-and-defect problem to the end users (i.e., target customers) who have less experiences on digital templates/platforms provided. They just know how to press the switch on the screen, some might read the manual clearly; page by page, whereas some might not. However, the primary problems are obviously shown through the personal perception on accessing and fixing the complex template and structure of digital items. Some users decide not to perform the tasks or follow the manual instruction documents by themselves when the errors are found. Asking the services from the professional staffs is the easiest way, and it is the only one solution that they really need. Doing this requires high-rate payment for the services; sometimes, they decide to buy a new item instead of fixing since the costs might be the same in both cases and cheaper [22].

2) Compatibility

One of the difficulties found is about "*tagging and monitoring by using sensors in the smart devices*" where the common information and standard like brand and specific types of sensors are not available as the regulations or standard documents to let manufacturers or suppliers apply properly for serving customers quickly and easily with high-quality services. Therefore, the simple platform and function of smart gadgets and applications are necessarily required for supporting all background levels (e.g., a universal-design concept as the USB or Bluetooth since it is not too difficult to do by themselves) [23]-[24].

3) Failure found

There are several opportunities for failure with complex systems. For example, when the online-application error, two customers may receive the same messages that the desired products are over (sold out) and these two customers may end up buying the same. But, actually, the items are available in the stock. The shop cannot sell products (lose money), and this issue might make the customers feel disappointed since something they hoped for or expected did not happen.

4) Privacy/Security/Safety

Currently, the stories about "*internet/computer hacker*" have become a big issue with IoT. Even if the passwords are required for all "*digital-access channels*", unfortunately, there is a chance that the software can be hacked and the personal information misused such as financial status that is not common knowledge launched to the social network [25]. The problem with the IoT is that there is no security standard. So, to purchase items from websites, all the safety risks become the consumer's responsibility [26].

When the users have expectations on how product will operate or where they can access it, the deviations from those expectations cause confusion. A few types of problems which are especially common in complex applications and make the users feel upset or annoyed are described as:

- Different words or commands for the same action
- Placing controls for the same feature in many different places

Therefore, according to the aforementioned statements, the proposed design of the IoT-smart bag should provide the functions of a temperature-controlled unit based on the "*design for maintainability*" concept, and, user's interface with an "*easy-to-access*" platform.

In order to accomplish the proposed research, a process called "product design and development (PDD) is required. Product design and development (PDD) has been introduced for identifying a market opportunity, clearly defining the problem of the existing design, developing a proper solution for that problem, validating the solution with real users, and supporting the users' requirements.

III. Product Design and Development (PDD) on "*Smart Bag*"

The key components related to how the traditional bag style deals with the concepts of "*keep it cool*" and "*lost and found*" have been raised and listed first

before creating the alternative design of the "*smart bag*". To successfully complete research, "*product design and development (PDD) with 5 phases"* has been applied as shown in Fig. 3.

Fig. 3. Product design and development (PDD) for "Smart Bag" application

In theory, design alternatives are aimed at minimizing the manufacturing cost and the complexity of the existing products; however, practically, it is quite difficult to create a new design if the designers do not know who their customers are, what they want, where they live and what they can afford. Simply saying that the success depends on being able to meet customers' needs and desires is not enough.

Seemingly, the data obtained from the target customers about their experiences on the existing products, and their expectations on a trend with the new innovations or designs cannot be applied immediately for forming the engineering-design platform. Since the customers do not really answer the questions about the size, color, shape or function of the product that could be extracted and revealed directly.

The process called "*translating needs to be designs*" has been applied firstly at the conceptual design phase of PDD. For example, when the answers implied something about classic tone colors, the designer might think about how to present the new trend that is far away from all-glossy white tone to flat/matte two-tone and three-tone schemes in neutral colors.

Therefore, to satisfy the target customers and to compete with the existing products, the customer perceptions and backgrounds can help designers to understand what they really want and what the trends of the new design should be.

A. Customer's Requirements and Perceptions

At the initial stage of the PDD which is conceptual design, from the researchers' viewpoints, the lists of key questions were raised and then launched to the target groups. However, the tough question was stated; *how many respondents are required for conducting a new design platform to accomplish this research topic?*

"*Google Forms*" were applied and sent to 150 people who live in/around *Bangkok metropolitan region*. Since, the importance level of their perceptions, and experiences about IoT devices might be considered as medium to high level. These data were translated later to be the drafted design of "*smart function*".

The researchers sent out 150 surveys and 125 were returned; this was about 83.33%. This might be a good starting point. A majority of survey respondents reported that they needed a good quality container for temperature-sensitive products; the products should be stored safely and the container should respond for the need in modern form with innovation. Launching an electronic form to the target customers would have been easier, however, personally interacting with people who have some experiences on the "*smart function*" gadgets would be great for a design perspective.

Engineering designers are naturally curious about how the product works, which means they ask a lot of questions to extract all components into product structure. Consulting with the experts who can explain the entire process/structure/situation from the very beginning and outline what would happen to the prototype after testing can help the designers find proper ways to start and decide which to use and when.

The "*physical form*" and "*technical features of a product to be manufactured*" have been addressed as the main issues in this study. After obtaining the answers from the surveys, the drafted model of an alternative "*smart storage bag*" was created and formed by the combination between "*Smart mode by IoT*" and "*Bag design adapted from traditional perception*". The desired characteristics of the "*physical form*" were listed as:

- having a lot of compartments for keeping small stuffs separated from the big ones
- good appearance with fashion colors and styles
- smooth bag handle and carry-on bag application
- good ventilation with double-sided storage bag, breathable storage or hollowed-out material design
- easy-to-access, and simple functions structures
- providing enough space for all the things we need for

According to the requirements from the target customers about the *physical form* of bags, the researchers had tried to review and analyze the specific characteristics of the various styles of the existing bags which are currently available in the markets (Table I). For the size of the bag, it is considered to be varied ranging from small lunch bags for individuals through to larger boxes and bags intended for family picnics. The roomy space inside the bag should contain many compartments for supporting a lot of stuffs. Illustrated in Fig. 4 is the insulated bag that was applied as the reference bag model for this case study; since this type of bag is a popular functional item that is used for temporarily storing and transporting foodstuffs. The incorporate insulation properties will keep the contents cool/hot prior to consumption.

TABLE I
THE EXISTING BAG PRODUCTS WITH MANY COMPARTMENTS

No.	Product	Functions					
		Keep Temp.	Hand Hook	Insulation Material	Sub space	Removable storage	Flexible
1	 **Name:** Portable Travel Makeup Cosmetic Bags **Size:** (W x L x H) – inch unit 9 x 7.5 x 3.35 **Price: $12.98** **[28]**	–	✓	✓	✓	–	✓
2	 **Name:** Makeup case ice cube mini rose gold **Size:** (W x L x H) – cm unit 18.5 x 23 x 18.5 **Price: $75** **[29]**	✓	✓	✓	✓	✓	–
3	 **Name:** Multilayer storage box portable suitcase **Size:** (W x L x H) – cm unit 18 x 28 x 22 **Price: $38.42** **[30]**	–	✓	✓	✓	–	–
4	 **Name:** Extra-large hanging toiletry bag with customizable storage **Size:** (W x L x H) – inch unit 12 x 9 x 5.5 and 43 extended length **Price: $27.99** **[31]**	–	✓	✓	✓	✓	✓
5	 **Name:** Paris Illustrated Makeup Bag with one main compartment **Size:** (W x L x H) – inch unit 8.5 x 6 x 2 **Price: $13** **[32]**	–	–	✓	–	–	✓

Fig. 4. The insulated bag (*Reference Model*) [27]

For the "*technical features*" the main considerations were emphasized on:

- Controlling temperature to keep the sensitive stuffs such as cosmetics, medical items, and baby food in a good condition
- Tracking the stuff's location
- Applying an automatic-moving mode for delivering or positioning purpose

Table I presents about the existing bag products that are popular for keeping stuffs.

B. The Technical Features of "Smart Bag"

Climate change influences severe weather by causing longer droughts and higher temperatures in some regions and more intense deluges in others. The properties of the temperature-sensitive products as lipstick, facial powder, hand cream or medicines might be deteriorated when exposed to severe temperature fluctuation. To create the new gadget or convenience option for supporting customers' needs (especially ladies) when they spend their time for driving car or travelling, "*smart-and-easy*" controlling system should be applied.

The definition of "smart" in this study will be mentioned as "*quickly and easily* adjusting *temperature inside the container*" *with less human intervention. However, leaving items inside the bag for a long period of time might totally destroy the physical properties of the sensitive products.*

The expected controlling-design system will be created according to these following considerations:

- Not only adjusting temperature inside the bag but also sending real-time notification (alerts) to the user via text on the mobile phone is quickly performed.

• The Arduino is required as a platform for microcontroller devices that makes embedded programming based on *easy-to-use* hardware and software.

• The temperature is controlled by *Blynk* application which is connected directly to smartphone.

• Data obtained from the experiment, and the properties of the sensitive products (from the reviewed articles) will be recorded, and then, these obtained data will be applied as the suitable temperature for storing item.

For definition of "*multipurpose storage bag*", it will be expressed as "*providing many slots or compartments to store the items and locate the cooling system properly*". Therefore, storage box or portable suitcase is recommended.

IV. Conceptual Design of "Keep it cool" Bag

After analyzing the results obtained from the self-administered questionnaires, the hidden needs were extracted and translated as:

• One of the secrets to attract people's attention is using a bag.

• Personal appearance is outstanding with exclusive bag.

• In terms of fashion and status, people (women) felt that their bag is definitely part of fashion image.

• If they get the wrong bag, it could ruin their fashion images.

• Bags have to meet functional criteria and provide lightweight structure and durable feeling.

• Bag should feature a round or oval shape.

• Hard-sided luggage is quite popular for travelling and the user can pack an amazing amount into it. Table II listed the product (bag) characteristics and definitions.

TABLE II
Product Characteristics and Definitions

Product Characteristics	Definitions
Quadrilateral	Storage bag has a quadrilateral shape.
Round	Storage bag has a round shape.
Simple	Storage bag can perform only specific operations.
Multifunctional	Storage bag can perform numerous operations and purposes.
Traditional	The mechanism is simple.
Automatic	The mechanism is high-technology.
Fixed	Storage bag is not able to carry.
Portable	Storage bag is able to carry.
Normal (Plastic)	The quality of the material is ordinary.
Excellent (Steel)	The quality of the material is exemplary.

From the aforementioned conditions, the conceptual design of the "*Keep it cool*" bag was created. Since the hard-shell or hard-sided luggage is made with high-tech plastics such as ABS and polycarbonate, which are lightweight and durable. ABS is the lightest, but polycarbonate is more durable. The most durable, but also the heaviest, is aluminum. This type of the bag can provide soft interiors (cloth bag filled with soft material), and hard-side expandable carry-on where its "outsider" external-mount handle provides a smooth packing area that might keep sensitive product in a good condition.

Therefore, the concept of "*hard-sided luggage"* was selected to be the reference design and structure for this study.

Fig. 5. The existing product of bag (*Hard-Sided Luggage*)

The lightweight and portable bag concepts were applied to the proposed design called "*Keep it cool*" or the developed design as shown in Fig. 6 which was inspired from the existing product. This design has been improved and combined the functions and shapes from the reference model (Fig. 5) and the first developed model where more functions in temperature controlling system and modification the appearance of the model to support the needs of users were added to the existing bag or container.

Fig. 6. Sketched model of the "*Smart Bag*" with dimensions

Product characteristics of the bag design were recommended by applying the adjective words as listed in Table III. After collecting data from the target customer and the reviewed information about the bag from the social media websites, the suggested guidelines for the conceptual model of the "*smart bag*" proposed in this study were listed in Table IV. Before going to the next phase where the components and sub-components are extracted and revealed in sequences (system-level design phase), the functions and physical characteristics of the expected design and the existing product should be compared (Table V). Moreover, the adjective words recommended could help the designer to find the proper direction to create the conceptual model of the desired prototype.

TABLE III
THE ADJECTIVE WORDS RECOMMENDED FOR CREATING NEW DESIGN OF MULTIPURPOSE STORAGE BAG

Customer's Requirement	Product Specification
1. **Price:** Expensive/Cheap	1. **Shape:** Quadrilateral/Round
2. **Appearance:** Modern/Classic	2. **Function:** Multi-functional/Simple
3. **Weight:** Light/Heavy	3. **System:** Traditional/Automatic
4. **Design:** Simple/Luxurious	4. **Carrying:** Fixed/Portable
5. **Size:** Big/Small	5. **Material:** Plastic/Steel
6. **Color:** Colorful/Colorless	6. **Extra function:** Tracking
7. **Surface:** Soft/Hard	7. **External:** Hard-Sided Luggage/Colorful Tone

TABLE IV
THE CONCEPTUAL DESIGN IDEAS FOR "SMART BAG"

No.	Idea of Multipurpose Storage Bag	Customer's Requirement	Product Specification
1		"Light" "Soft" "Small" "Classic"	"Round" "Portable"
2		"Modern" "Luxurious"	"Multi-functional" "Portable"
3		"Colorful" "Light" "Cheap" "Small"	"Round" "Multi-functional" "Automatic" "Portable" "Plastic"

TABLE V
COMPARISONS ABOUT FUNCTIONS AND DESIGN OF TWO STYLES OF BAG

Functions & Design	"Keep it cool" Model	"Reference" Model
		
Storage Normal Products	✓	✓
Storage Sensitive Products	✓	×
Portable	✓	✓
Control Temp.	✓	×
Maintain Temp.	✓	×
Small Size	✓	✓
Light Weight	✓	✓
Modern	✓	✓
Multi-Function	✓	×

V. SYSTEM-LEVEL DESIGN AND DETAILED DESIGN OF "KEEP IT COOL" BAG

After obtaining the guidelines about "smart bag" characteristics from the previous stage, constructing the components and sub-components in sequences is required. This section presents about two phases of PDD: *system-level design*, and *detailed design* where the main components of the desired "smart bag" are firstly created into 2D-image forms, and then, these details will be applied as the recommended information for creating the prototype in the next phase. Visualizing and applying the IoT platform to the right position on the physical design of the bag can help the designer easily to specify the details of each component properly; for example, the fan will be attached on the topmost area of the bag for releasing hot air inside the bag when the temperature controller starts working. However, the expected results, usually, are shown through the intangible satisfaction scales/levels judged by the target customers.

For *physical shape* of the proposed design, there are 3 main parts: *body*, *storage space*, and *bucket fastened bag strap* (Fig.7). Each part requires different components materials. Additional, material selection is one of the important factors to create or recommend the physical characteristics of the model that is being designed.

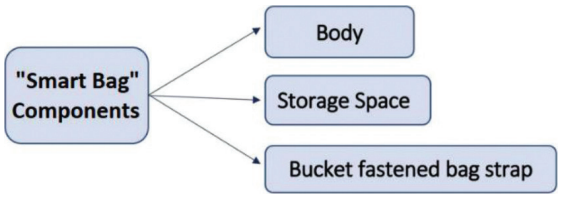

Fig. 7. Drafted configurations of physical model

A. Body

For *the body*, it consists of plastic handle, zip, cooling fan and bag side clip buckle handbag as shown in Fig. 8 and 9. Providing easy-to-carry concept of handbag with lightweight and water-resistant material is one of the most important aspects of the body platform. The storage box consists of three main parts which are *body*, *storage space*, and *bucket fastened bag strap*. The dimension of expected product is around 15 cm x 30 cm x 21.5 cm. The expected design will be round corner square shape with a luxury color and able to carry easily. The main raw material used to produce the product is plastic. Additional functions will be included for multipurpose used.

For *plastic handle*, ABS plastic is recommended since the benefits of products made of ABS plastic include *strong impact resistance*, *strong heat resistance,* and *lightweight.* In this study, the zippered compartment on the exterior to lock the bag is applied because it is effective security features that is anti-theft bags.

For *cooling fan*, the heated air will be removed away from inner space of the bag and expel hot temperature to outside.

For *bag side clip buckle*, the designers decided to apply the plastic D-Ring buckle which can be attached to the belt and textured grip easily for being used with easy-break-away feature. It is quite strong and durable enough for carrying and keeping sensitive items in a good condition since it is made from zinc alloy.

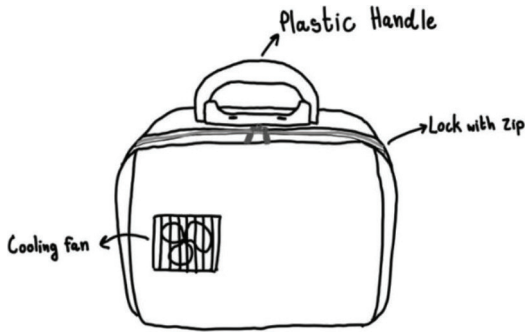

Fig. 8. Sketch body model-Frontal Area

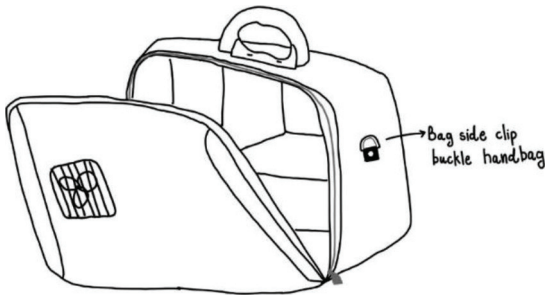

Fig. 9. Sketch body model-Interior Design

B. Storage space

Referring in Fig.10 and 11, it is the storage space (compartments) of the expected design made from *High-Density Polyethylene (HDPE)* plastic. This is divided the room or space into 3 cells for storing different type of items and protecting possible damages caused by impact between items. Moreover, it can be taken off easily for cleaning.

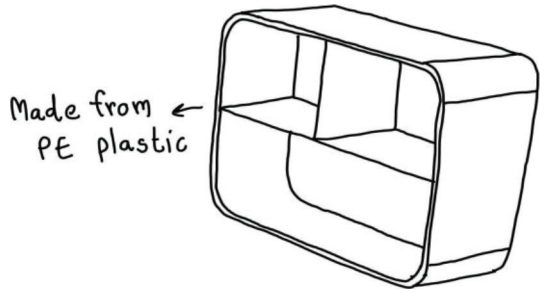

Fig. 10. Sketch of partition/storage space model

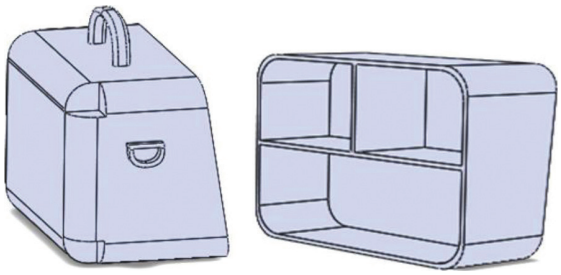

Fig. 11. Storage Space and Body of the designed bag (virtual form)

C. Bucket Fastened Bag Strap

For *bucket fastened bag strap*, the components required are shoulder strap pad, hook buckle and nylon belt as shown in Fig. 12.

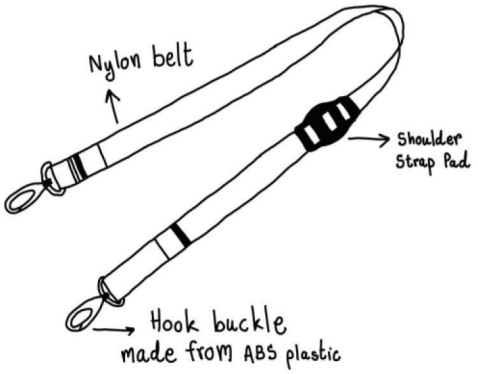

Fig. 12. Sketch bucket fastened bag strap model

For *shoulder strap pad*, it is used to provide a comfortable cradle for a shoulder strap for carrying the luggage case includes a foam pad and an elastic webbing firmly attached to this foam pad. We used nylon belt because it is exceptionally strong, relatively resistant to abrasion and moisture absorptivity, long-lasting, resistant to chemicals, elastic, and easy to wash. Nylon is often used as a substitute for low-strength metals.

For *hook buckle*, it is a one of the additional options to easily carry on this bag since it is very durable, superior stiffness and strength.

Since the new design of the multipurpose/smart bag "*Keep it cool*" contains three main components which are *body*, *storage space*, and *shoulder strap*, each component needs to be extracted its subcomponent(s) in details such as the specific material used, and the digital/instrument component(s) required for each automatic-smartmovement. This section will present about the components and sub-components required for creating the prototype of the smart bag.

The outer profile of the smart bag component is attached with shoulder strap and storage space inside. The body contains the temperature controlling system. For the storage space, this component is attached to the housing (body) which keep the stuffs in place.

For the *shoulder strap*, this component is attached with body that supports the portable function.

From the diagram (Fig. 13), creating the storage bag might use different materials for each part. The material selection for the main components of the "*smart bag*" are listed in Table VI.

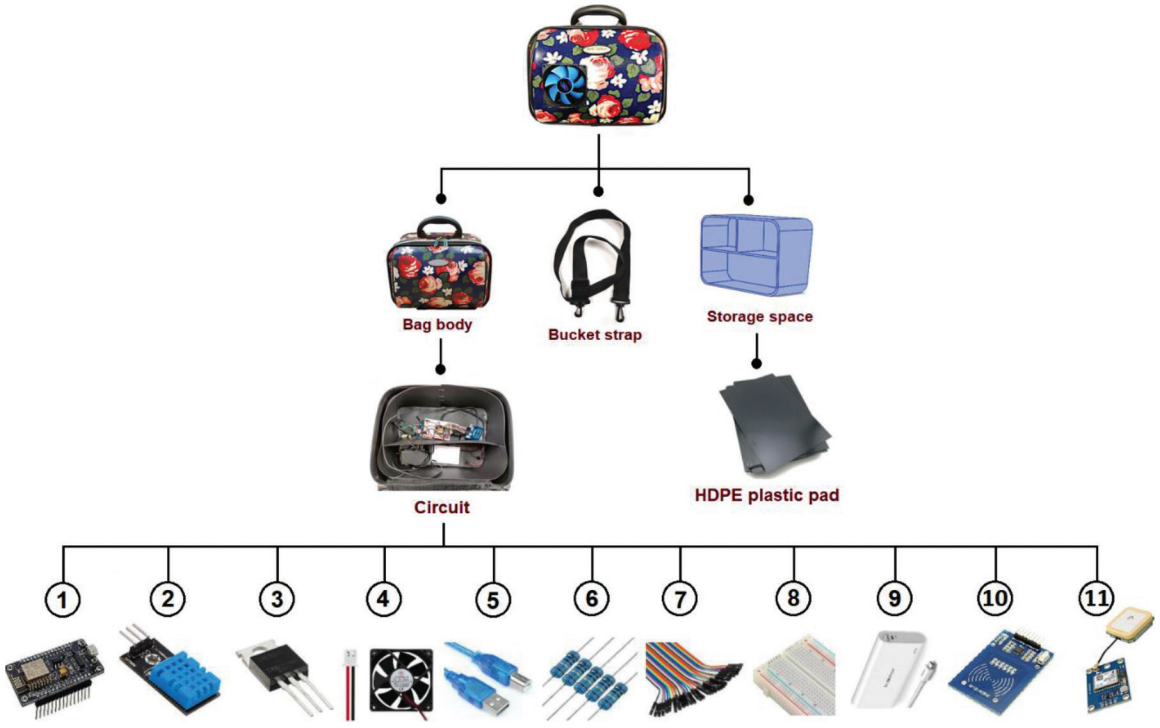

Fig. 13. System level design of the storage box

① **NodeMCU Version 2 (ESP8266-12E)** - The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. Therefore, NodeMCU is an open source platform based on ESP8266 which can connect objects and let data transfer using the Wi-Fi protocol [33].

② **DHT11 humidity and temperature sensor module -** This sensor is a basic digital temperature and humidity sensor. It uses a capacitive humidity sensor and thermistor to measure the air and transfers a digital signal to the data pin [34].

③ **IRF3205 (Fast Switching Power MOSFET Transistor) -** It is used for fast switching purpose. IRF3205 has been introduced by international rectifier. The main objective of introducing this device is generating extreme low on resistance per silicon area. This is a very common MOSFET with very low on-resistance and a control voltage that is compatible with any 3-5V microcontroller or mechanical switch. This allows you to control high-power devices with very low-power control mechanisms [35].

④ **Cooling fan/Axial fans** - The propellers (fan blades) located in the circular flow path between the cylindrical hub and casing are used to force-feed air in order to generate air flow in the direction of the axis of rotation [36].

⑤ **Micro USB cable** - Plugs into any USB 2.0 port to charge portable devices. Compatible with most devices with a Micro-USB port. For charging and syncing for data transfer [37].

⑥ **Resistor, 270 Ohms, error 1%** - Commonly used in breadboards and other prototyping applications [38].

⑦ **Jumper wire** - Use these to jumper from any female header on any board, to any other female header. Combine these with our female to female jumpers to create a male to female jumper. Multiple jumpers can be installed next to one another on a 0.1 header [39].

⑧ **Bread board** - This is a small half-size bread-board, good for small projects. It has the standard double-strip along the center and two power rails on both sides. The rails will peel off to become even smaller should you need to stick it onto an Arduino protocoled [40].

⑨ **Power supply (Power bank) -** Power banks are used for providing portable power to charge battery powered items like mobile phones and other similar items that have a USB interface: they can charge via USB, or wirelessly [41].

⑩ **Radio Frequency Identification -** This system uses for defining that the items are took into the bag or took out from the bag [42].

⑪ **GPS -** This system uses for tracking the current position or location of the bag [43].

TABLE VI
MATERIAL USED FOR EACH PART

Function Part	Material Used
Bag body	Polyvinyl chloride
Handle	Acrylonitrile Butadiene Styrene (ABS)
Hook Buckle	Acrylonitrile Butadiene Styrene (ABS)
Belt	Nylon
Shoulder Strap pad	Nylon
Bag side clip buckle	Zinc alloy
Storage space	High-Density Polyethylene (HDPE)
Zipper	Nickel

VI. IOT PLATFORM ON "*SMART BAG*"

For *software/controlling part*, two programs which are *Arduino*, and *Blynk* are applied for creating the temperature controlling system. Arduino was asked to write the code whereas another program was applied to design the application on the smartphone. The details of each component were expressed into steps where some problems found or mentioned could be applied for design and development phase.

A. Blynk Application

Blynk is an IoT platform which can control, and monitor the interactions among digital components. For the industrial viewpoints, Blynk is the scatter of IoT, and it provides a set of order in the libraries and a cloud server. The applications of Blynk can be mentioned as the tool for connecting with an *Arduino* (Ethernet shield), an *esp8266 baseboard*, and/or a *Raspbery PI*. Moreover, Blynk can create and upload the sketch with *Arduino IDE*.

The sketch with the Blynk libraries will create a connection between the Blynk device and the Blynk server. On the front-end side we can access the Blynk from a mobile app where we can design the user interface for the project. The lens kit can get more complicated by running the own local Blynk server for more flexibility and security and all of them are for free. Important to note that Blynk app is really a UI front-end which there are widgets for buttons sliders, joystick display elements, and graphs gauges. Notification tools available in the app to control the devices and display values from those devices and any logic needs to be implemented in C++ code running on the IoT device. Fig. 14 is the Blynk platform with iOS and Android applications to control Arduino, Raspberry Pi and the others via Internet channel.

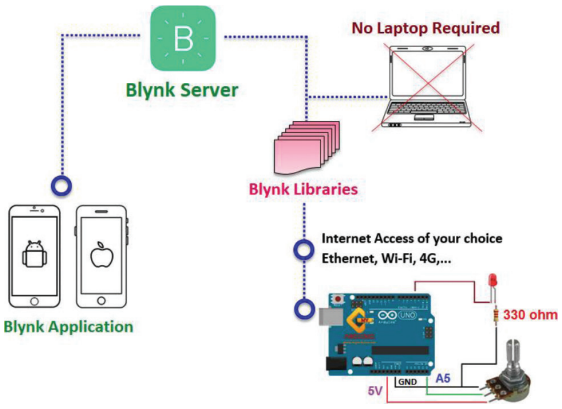

Fig. 14. System of Blynk

The application will be used to set the desire temperature, humidity, and display the current temperature, and humidity. Blynk is uncomplicated and easy to apply user interface, easy to create the project via mobile phone and with the cloud service it works from anywhere by phone.

The other important note is not using local server and it is easy way to share the projects that again is really easy and a neat feature which provide access to project for other to use. Furthermore, Blynk is almost free. The libraries are free, the Arduino IDE is of course free, the mobile app is free, the Blynk cloud account is free, and will get a vibrant and very helpful community.

Illustrated in Fig. 15 is the graphical simulation of Arduino platform where the fan is applied as the output device to ventilate the air inside the system. The display represents the mobile screen where the temperature condition of the system is shown after simulating.

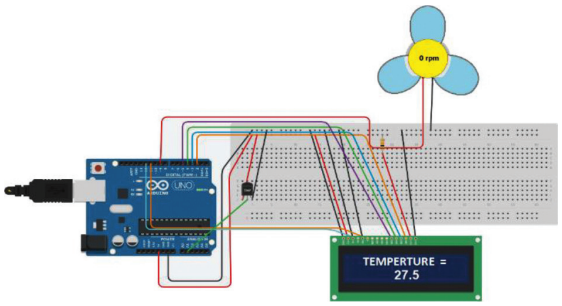

Fig. 15. Wiring connection between components

B. Functions Required for "Smart Bag"

The function of the storage is to measure temperature and humidity which can control temperature inside storage box by using smartphone to control system in which the temperature measured are performed on display of smartphone. Moreover, the storage box can be portable to outside and can connect with wi-fi or personal hotspot.

The *Blynk* application is applied in this study to control, maintain, and monitor the conditions inside the bag (i.e., temperature, humidity, and moisture). For example, when the user sets all conditions of the bag with the default or recommended values, the lipstick kept inside the controlled bag deforms its shape and starts melting, there is obviously something wrong with it, this error condition is linked to Blynk notification immediately to show some messages to the user's phone as illustrated in Fig. 16.

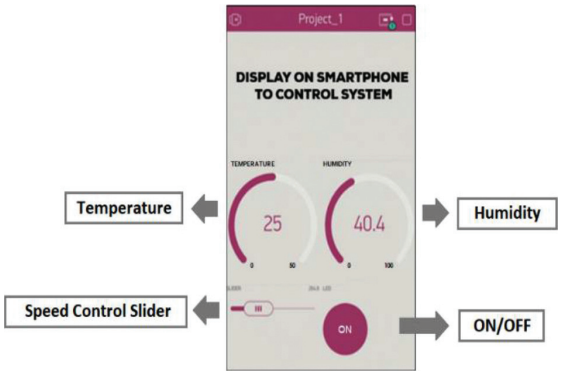

Fig. 16. Display on smartphone

In the Blynk application, three modes; *automatic*, *manual*, and *lost and found* modes, are available (Fig. [17]-[19]). One of the good reasons to apply this application is that the user can control the temperature inside the bag by adjusting speed of the fan on "*Slider Button*" in Blynk application from anywhere around the world, and at any time that the user wants.

The notification will be shown the mobile screen for letting the user knows about the condition on the controlled items immediately when the measured value is higher than the setpoint value.

For the "*automatic*" mode, the system can automatically maintain the temperature inside the bag to match with the recommended value (i.e., the setpoint or reference value).

Whereas, for the "*manual*" mode, it needs to switch the assigned conditions for each particular object manually that is being kept inside the bag (i.e., switching *lipstick* to *powder* functions) where the "voice controlling mode (Google Assistant)" was assigned and applied in this mode for making the user's life easier (Fig.19).

For the "*lost and found*" mode, the locations of the bag and stuff inside can be identified. The notification for announcing the defected items or failed conditions occurred can be quickly shown on the screen of the mobile phone.

The components required for "*Smart Bag*" are shown in Fig. 20. The prototype of "*Smart Bag*" was shown in Fig. 21 and Fig. 22. The details of "*automatic and manual modes*" will be presented and discussed.

For "*automatic mode*"

The steps required for automatic function can be expressed as:

Step 1: Name the product (**No. 1**) as "**Lipstick**" into the program (code) for creating selection "**Button**", then the mobile screen will show the "**Lipstick Button**" function.

Step 2: Set the temperature for keeping the product (**No. 1**), "**Lipstick**", in a good condition as "**25 ºC**".

Step 3: Press the "**Lipstick Button**" to start the automatic temperature control.

For the product (**No.2**); "**Powder**" can be added as the name of "*selecting button*" where the other requirements will be followed the previous steps. However, the temperature is changed to be "**28 ºC**".

For "*manual mode*"

The meaning of "*manual mode*" in this study is that the values of temperature required for supporting the functions of "lipstick" and "powder" can be adjusted manually by using the "slider bar" or "voice control" commands.

After adding the function of "*manual mode*" where the "*slide bar*" is the key component, then the user can follow these following steps:

Step 1: Press "**Manual Button**"

Step 2: Move the "**Slide Bar**" manually to set the temperature for keeping the product such as "**Lipstick**" at any desired value; "**28 ºC**".

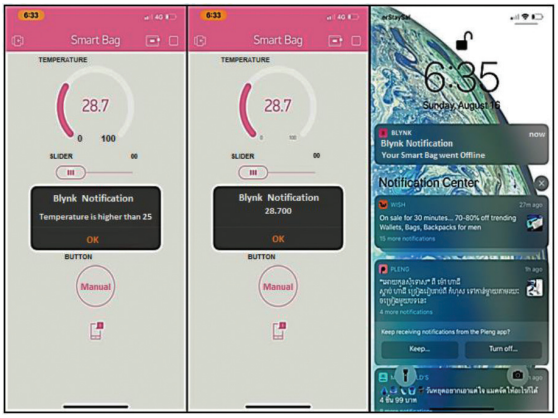

Fig. 17. Blynk notification

(a) (b) (c)

Fig. 18. User-interface on mobile application; before (a and b) and after switch to manual mode (c)

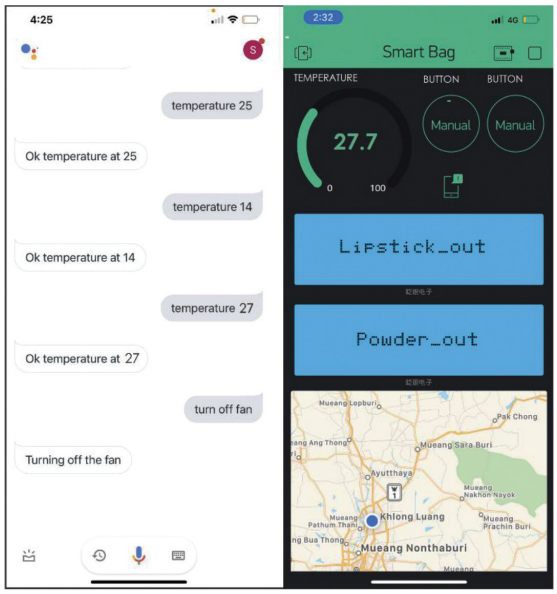

Fig. 19. User-interface on mobile application of blynk and voice control system

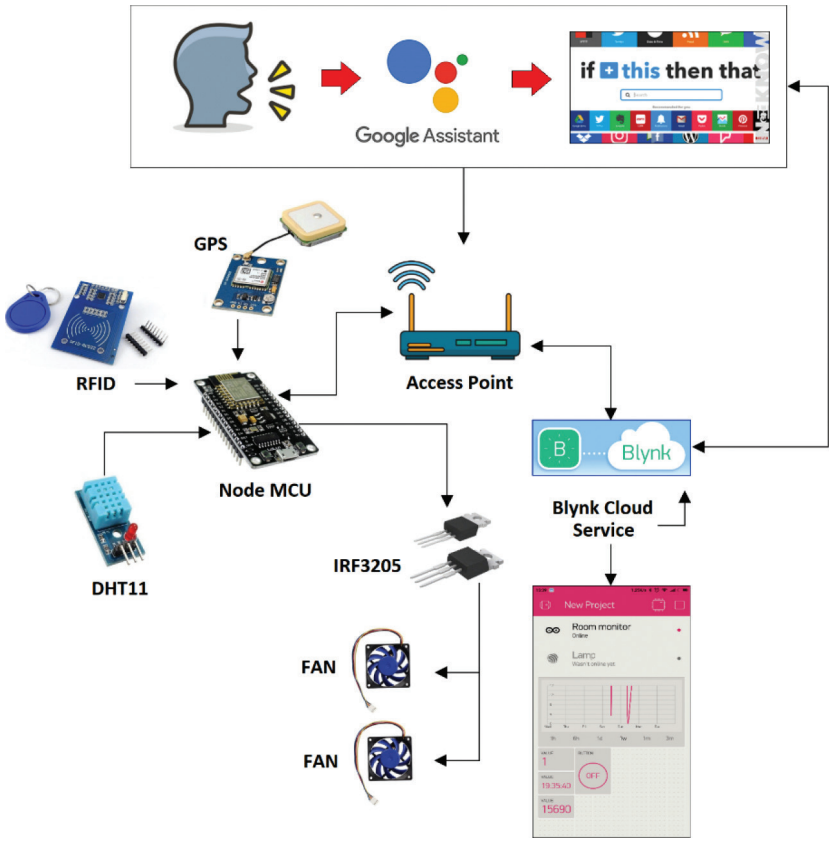

Fig. 20. The components required for "Smart Bag"

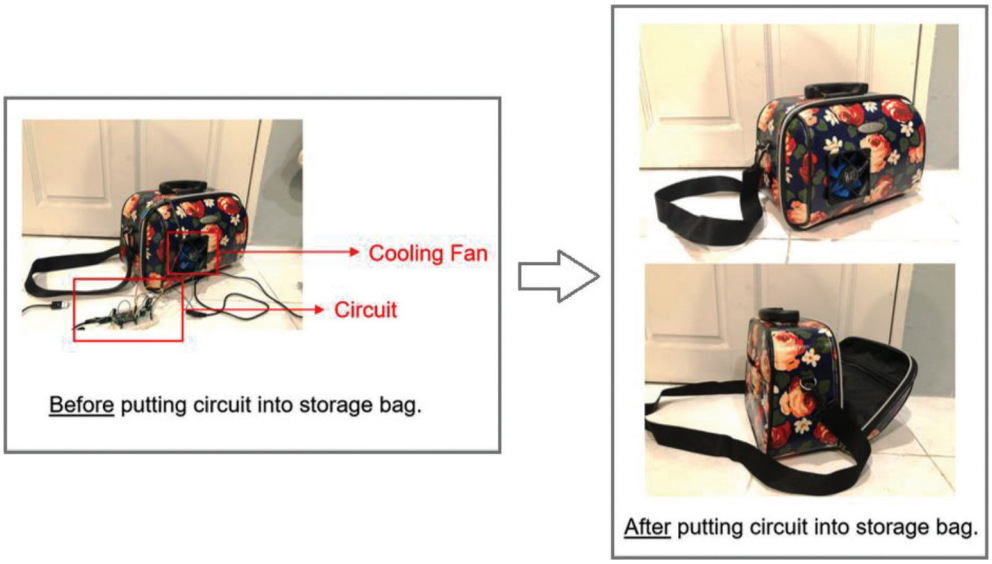

Fig. 21. Adding "IoT" into "Smart Bag"

Fig. 22. Four views of the "Smart Bag" prototype

VII. Refinement and Testing

Since the objective of this research is about developing and transforming the traditional style of the bag, the alternative "Smart Unit" has been introduced where the temperature inside the bag can be adjusted easily to support a sensitive item, and the additional functions called "*Lost and Found*" are inserted into the main frame of the prototype platform to check the location of the bag. In order to accomplish the proposed idea of this research, after creating the prototype, testing activity has been performed.

For the action of the "Smart Bag", the constraints were constructed as:

- When the temperature inside the bag varies and it is differentiated from the reference value, the system starts to send the command for turning the fan on for reducing the temperature inside.
- After turning the fan for a while, the temperature reaches the setpoint (reference) value, the sensor sends the data to the controller for stopping the movement of the fan.

For testing and checking the ability of the "Smart Bag", these considerations have been raised:

- How fast that the system can bring the temperature back to the normal stage (the setpoint/reference value)?
- The accuracy of the system can be checked by comparing the reference value and the measure one.

A. Conducting Experiment

The experiments were started by collecting the data of temperature indoor and outdoor at different locations. The results were listed in Table VII where the average value was used to set the reference point to control the system in the automatic part.

The conditions were made as:

- The setpoint (reference point) was set to be 27 °C.
- The testing had been conducted for 3 days.
- Each day, 5 data sets were recorded at 8, 10, 12, 14, and 16 o'clock.
- On each set, it contains 1-hour period.
- Each 1-hour period requires 10 minutes for each measuring activity. So, the test will be performed 6 times/hour.
- The acceptable range of the temperature is 27-28 °C. When the temperature inside the bag is detected to be higher than 28 °C, the fan starts moving until the temperature reaches 27 °C again.
- The air flows into the bag through gaps between zipper and flows out through the fan.
- The digital thermometer and the sensors were used to determine the temperature values inside the bag.
- After collecting the data from those 3 days, the results were analyzed; mean and variance of the data were calculated to find the appropriate temperature condition in this study.

The aim of this testing is about checking the temperature inside the bag after the fan stops moving.

From the results, the temperature value was decreased around 1-2 °C after the functions inside the bag were active for 3 minutes, and the humidity was also decreased.

For 1-hour period, the measuring activity performed 6 times; the temperature inside the bag had been collected for every 10 minutes (between 8:00 am to 8:10 am). Table VII presents some part of the entire data (3-day collections) that were recorded from 8 a.m. to 9 a.m.

TABLE VII
Six Datasets From The Experiments (8 to 9 a.m.)

No.	Time (AM)	Measured Temp. (°C)	
		read by sensor	read by thermometer
1	(8:00 - 8:10)	27.5	27.3
2	(8:10 - 8:20)	27.4	27.4
3	(8:20 - 8:30)	27.5	27.6
4	(8:30 - 8:40)	27.1	27.3
5	(8:40 - 8:50)	27.2	27.2
6	(8:50 - 9:00)	27.4	27.3

B. Calculating Error

The temperature inside the bag was applied as the key consideration, after applying the developed system, it could be slightly changed to meet the setpoint. Since, in this study, only one fan was used for performing the basic function of moving air from one space to another, the time spent for changing stage was about 3-5 minutes per (-1) °C; reducing in 1 degree Celsius. For the future works, adding more fans into the system could provide enough additional airflow in the system, the temperature inside the bag might be reduced faster.

In order to check the performance of the bag system, two types of error calculation were applied; *percent error*, and *percent difference*.

1) Percent Error Calculation

Percent Error is applied when an experimental quantity, "*Measured Temp.*", is compared with a theoretical quantity or the setpoint, "*Reference Temp.*", which is considered as the "correct" value. The percent error is the absolute value of the difference divided by the "correct" value times 100 [44]-[45]. The formula of percent error is shown in *Eq.(1)*.

$$\% \text{ error} = \left| \frac{(Mea.Temp.) - (Ref.Temp.)}{(Ref.Temp)} \right| x\ 100 \qquad Eq.(1)$$

Where,

Ref.Temp. is the reference temperature (27 °C)
Mea.Temp. is the measured temperature
% diff. is the percentage error

Percent errors can explain about how big the errors are when we measure temperature in an experiment. Smaller percent errors mean that the result of the system (i.e., temperature condition inside the bag) is close to the accepted or real value (the setpoint; 27 °C). While bigger percent errors means that we were quite a long way off from the true value. The results of "*Percent errors"* calculation was shown in Table VIII.

TABLE VIII
PERCENTAGE ERROR CALCULATION

No.	Measured Temp. Versus Ref. Temp. (27°C)			
	Read by sensor	Percentage Error (%)	Read by thermometer	Percentage Error (%)
1	27.5	1.83	27.3	1.10
2	27.4	1.47	27.4	1.47
3	27.5	1.83	27.6	2.20
4	27.1	0.37	27.3	1.10
5	27.2	0.74	27.2	0.74
6	27.4	1.47	27.3	1.10
Avg.	***27.35***	***1.2864***	***27.35***	***1.2869***

In conclusion, at 8:00 am – 9:00 am, the system could perform nicely to adapt the temperature inside the bag for hitting the reference (setpoint) value. When the temperature inside the bag reached the setpoint value, the system performed "inactive" mode, the fan ran for a few seconds, and then it turned off.

The values of measured temperature obtained from "sensor", and "thermometer" presented slightly different from the reference value where a 1.29% error means that the system got very close to the accepted value (27°C).

Applying percent error calculation will explain about how badly these unavoidable errors affected the results.

2) Percentage Difference Calculation

If we would like to compare the two datasets of the temperature values measured from the sensor and the thermometer, "*percentage difference*" is applied. *Percent difference* is practically the same as percent error, only instead of one "*true*" value and one "*experimental*" value, the two experimental values are compared. The formula is shown *Eq. (2)*:

$$\% \text{ diff.} = \left| \frac{Measured_1 - Measured_2}{\left(\frac{Measured_1 + Measured_2}{2}\right)} \right| x\ 100 \quad Eq.(2)$$

Where,

$Measured_1$ is the measured temperature from sensor
$Measured_2$ is the measured temperature from thermometer
% diff. is the percentage difference

Percentage difference (% diff.) equals the absolute value of the change in value, divided by the average of the 2 numbers, all multiplied by 100. Then the percent sign, %, is added at the end to designate the % difference [46]. The results of the percentage difference were shown in Table IX.

TABLE IX
PERCENTAGE ERROR FROM THE EXPERIMENTS (8 TO 9 A.M.)

No.	Measured Temp. (°C)		Percentage difference (%)
	Read by sensor	Read by thermometer	
1	27.5	27.3	0.73
2	27.4	27.4	0.00
3	27.5	27.6	0.36
4	27.1	27.3	0.74
5	27.2	27.2	0.00
6	27.4	27.3	0.37
		Average	***0.37***

The expected result is to keep the sensitive product in a good condition, and it can be preserved its original condition. However, the fact obtained from this study is that the measurement errors are mostly unavoidable where the equipment can beinaccurate, imprecise or the instruments applied just might not have the capability to measure accurately.

IX. CONCLUSION

The aim of this study is to develop new design of "*smart bag*" that can help users to preserve the sensitive products such as cosmetics, foods or some kinds of the medicines in a temperature-controlled bag/container. The IoT application will be added properly into a roomy compartment of the bag where the physical characteristics (e.g., shape, size or color) are recommended from the concept of PDD.

According to the advantages and disadvantages of IoT mentioned and reviewed earlier, the researchers have tried to develop and modify the alternative functions and devices for saving the consumer time and money while improving the quality of life and health. The ability to access information from anywhere at any time on any device is the main key

component for the proposed IoT application. When IoT platform is applied, the communication between/ among people or connected electronic devices can be improved where the way and method applied to transfer data from the automating tasks are quite simple and easy. The quality of a business's services improved while the need for human intervention is also reduced.

Although IoT has quite a few disadvantages, its advantages of improving a quality of life cannot be denied where the time spent and error found during performing the redundant tasks can be reduced or eliminated. The applications of IoT can be seen commonly in both households and companies. The benefits obtained from the case study presented in this research can be briefly expressed as;

"Smart Bag" can support the people to keep the sensitive cosmetic products in a good condition for travelling to another province/place. To *keep their product cool*, the smart bag can be adjusted, controlled the temperature and humidity conditions inside the bag easily and properly via smart phone application. Applying this will not damage and destroy the physical or chemical properties of the products comparing to the traditional insulated bags. IoT can make the world and life easier with simple setting convenient functions applied.

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