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Internet of Things Ultraviolet Sterilizer Receiver Box: How to Design and Construct?

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Article Info	Abstract
	COVID-19 is a virus that can spread through objects and depending on environmental conditions. It can last for several hours without destroying structures or disintegrating. Due to the COVID-19 pandemic, people were restricted from going outside to buy essential goods. Based on these conditions, it is necessary to design an IoT-based virus-safe package receipt box that is intuitive and comfortable for users to use, whether sending or receiving packages. People can control the system via remote control. Sterilization is carried out intelligently by considering the packet received. Design and construction of Internet of Things Ultraviolet Sterilizer Receiver Box use the Design Science Research Method. The methods consist of six stages: identify problem & motivate, define the objective of a solution, design & development, demonstration, evaluation, and communication. There are three parts of the system: sterilizer receiver box, mobile application, and Internet of Things. The system successfully passes the five testing scenarios: package received detection, package retrieved detection, ultraviolet irradiation, data service, and locking. The IoT-based virus-safe package receipt box can help maintain public health by preventing the COVID-19 virus with ultraviolet sterilization and supporting a modern lifestyle where people who work when the package arrives do not have to worry about the packages arriving.

INTRODUCTION

The COVID-19 pandemic in 2020 has created a public need for a safe, healthy, and modern supply chain system for essential goods [1]. Concern about virus transmission has caused difficulties in goods delivery from sender to receiver/consumers [2]. There is no guarantee that harmful viruses do not contaminate the good's delivery [3]. Such conditions have caused consumers to reduce their consumption levels so that it also impacts the stability of the business [4]. Many businesses shut down during the pandemic, including Indonesia [5].

The COVID-19 pandemic since the end of 2019 has forced humans to increase their vigilance against the virus [6]. Based on studies, COVID-19 as a virus can spread through objects and, depending on environmental conditions, survive for several hours without breaking down or disintegrating [7]. Coronavirus can multiply to cause more

severe infections and organ failure [8]. Furthermore, because of their tiny size, viruses can survive on the surface of objects [9].

One aspect that has been severely affected by the COVID-19 pandemic is the supply chain of public goods, where public fear and the existence of lockdown policies in various countries have caused an economic slowdown and decreased public consumption levels [10]. Some of the adjustments that were detected by industry and society in the first few months of the pandemic were the increasing digital behavior in both production and consumption lines and the increasing demand for technology that can provide a sense of security in the supply chain system [11], [12]. With the high uncertainty about when this pandemic will end, many experts also predict that some behavioral changes will become long-term and permanent changes [13].

The supply chain system that supports online purchases must be considered carefully [14]. Many online delivery service providers to consumers, but no one has provided security and health guarantees, especially from the risk of transmitting dangerous viruses [15], [16]. Delivery services has to have policies such as sterilization in the form of spraying disinfectant liquid on incoming and outgoing packages and urging their customers to clean or wash the box's contents before use [17], [18]. Many studies have studied how to sterilize objects at risk of being exposed to viruses, especially COVID-19 [19]. One of the most effective ways to prevent the COVID-19 virus is to use ultraviolet light [17]. Ultraviolet light can damage the structure of the virus so that it cannot infect human cells [20]. We can use ultraviolet light to sterilize viruses on objects [19], [21]. UV light has been known to inactivate viruses and bacteria by exposure to the emitted waves [22].

Based on a preliminary study, the wavelength of UV light that can inactivate the coronavirus is 254 nm [21] and has a better effect than chemical-based disinfectants. Therefore, its effectiveness needs to be evaluated to ensure the quality of the disinfectant product [23]. Many sterilization products also use boxes with ultraviolet light [24]. However, there has been no research on goods receiver boxes using IoT, which sterilizes viruses using ultraviolet light and remote-controlled using a mobile system for the people who use delivery services. These systems can be portable or stationary.

Research on IoT-based virus secure packet receipt boxes can lead to innovative and original products. People can operate the system via remote control in which intelligent sterilization is committed based on the package received. This paper is one of the first policies such as sterilization in the form of spraying disinfectant liquid on incoming and outgoing packages and urging their customers. This paper can be viewed as 'real-time sample' as it provides insights and lessons for all stakeholders to improve and adjust existing policy options mainly at the national level. Therefore, the research aims to create a prototype system as a proof of concept for the Internet of Things Ultraviolet Sterilizer Receiver Box.

METHOD

The development of the prototype span across six months period. In this research, we use the Design Science Research method consisting of six stages [25]. Identify problem & motivate, define the solution's objective, design & development, demonstration, evaluation, and communication are shown in Figure 1.
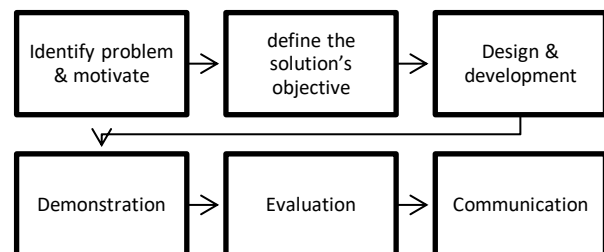
Figure 1. Directory Services Restore Mode (DSRM) Process Model

Identify Problem & Motivate

In this step, the studies on the conditions and needs in the pandemic were carried out to answer the issues found. The state of the COVID-19 pandemic has made the public critical of viruses that are harmful to humans. With so many goods package delivery services happening in the community, there is concern about viruses attached to goods packages. Based on studies, viruses in general, such as COVID-19, can be destroyed if exposed to ultraviolet light. Thus, securing the package

through ultraviolet irradiation sterilization can be considered a solution.

Define The Solution's Objective

The next step in this research is to determine user needs in detail and explicitly. Based on the existing problems, the aim is to build a solution to protect packages from viruses using ultraviolet light. Artificial ultraviolet light can be effectively used when space is limited. The goods package receipt box is chosen to work optimally with ultraviolet light. However, it must be considered how to stay intuitive and accommodate the lifestyle of modern society, which tends to work and not be at home and constantly connected via the internet. IoT can be used to accommodate this. User requirements formulated from the above conditions are as follows:

a. Receiver Box must be able to sterilize using ultraviolet light.
b. sterilization must be done intelligently based on the package received.
c. Package deliverers can safely deliver packages without direct interaction with package recipients.
d. The recipient of the package can know the package has arrived and is sterilized.
e. The virus-safe packet receiving box must secure the package from unauthorized persons.

Design & Development

The prototype aims for the minimalist development of a concept. Prototypes represent ideas to be tested and understand the conditions that occur. At this stage, the prototype is made in two parts, namely:

a. Internet of Things Ultraviolet Sterilizer Receiver Box
   Internet of Things Ultraviolet Sterilizer Receiver Box has two-door slots for the delivery man (Figure 2) and the recipient (
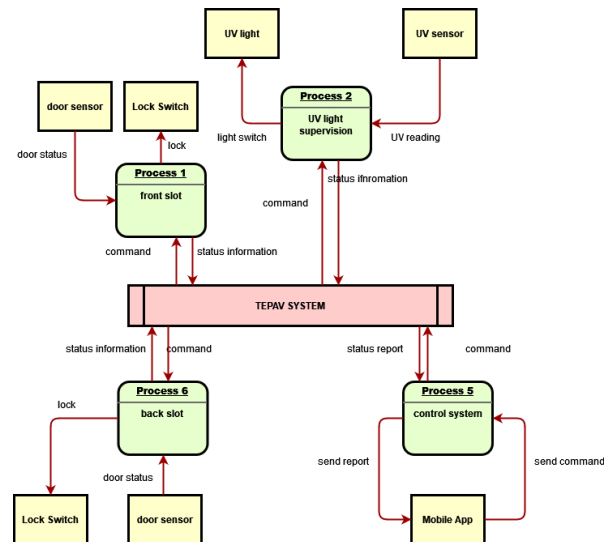
   Figure **3**).

Figure 2. Box with an open delivery slot

Figure 3. Box with open recipient slot

b. Ultraviolet Sterilizer Receiver Box Mobile Application
   Ultraviolet Sterilizer Receiver Box Mobile Application has the following features:
   1. Authentication
   2. Locking system
   3. Ultraviolet surveillance
   4. Notifications

Figure 4. Internet of Things Ultraviolet Sterilizer Receiver Box system

Demonstration

Ultraviolet Sterilizer Receiver Box developed based on the design in this stage.

Evaluation

Tests are carried out at least ten times on the following scenarios:
a. Package received detection
b. Package retrieved detection
c. Ultraviolet irradiation
d. Data services
e. Locking

Communication

Finding in the research are reported in this stage.

RESULT AND DISCUSSION

The latter three DSRM stage results are presented here.

Demonstration

After the design process, a box prototype of wood is made according to the initial design concept. The prototype for the box can be seen in Figure 5.

Figure 5. Box prototype

Inside the box is the Internet of Things-based electronic circuits. The electronic circuit in the device consists of:
a. Light-based object detection sensor;
b. Door sensors;
c. UV sensors;
d. Temperature and humidity sensor (DHT22);
e. Relays;
f. UV light;
g. Solenoid door lock;
h. Power adapter; and
i. ESP32 mainboard.
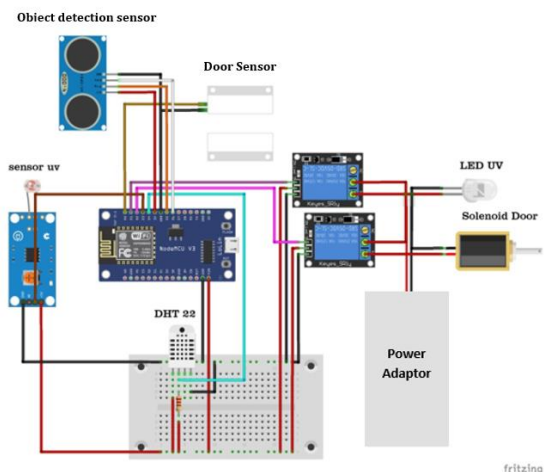

Figure 6. Electronic circuit

For the database, data stored contain:
a. User data;
b. Action;
c. Sensor readings;
d. Mac-address;
e. Auto mode;
f. Wi-Fi status, and
g. Sterilization duration.

All sensors and actuators are controlled by an ESP32 board connected directly to the cloud database via a Wi-Fi network. The implementation of the electronic device can be seen in Figure 6. The data structure can be seen in Figure 7 below.
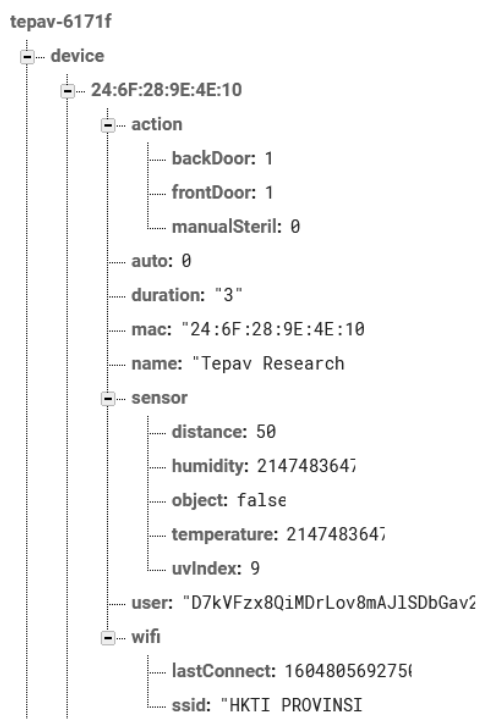
Figure 7 . Data structure

Evaluation

This stage tests the prototype of the Internet of Things Ultraviolet Sterilizer Receiver Box system and direct testing of the package receiving process. The aims are to test the prototype in the field. Testing is done after all components are integrated into one including the entire program that has been created. Testing is carried out by running the system according to the procedure and observing the performance of the system that begins with setting the sterilization timer at the minimum position and recording the result Results can be seen in Table 1.

Table 1. Integrated Testing

No.	Test scenario	Result
1	Package received detection	Pass
2	Package retrieved detection	Pass
3	Ultraviolet irradiation	Pass
4	Data services	Pass
5	Locking	Pass

After studying the test results, the right features were adjusted. The right technology is considered based on the limitations of the IoT system. The Internet of Things (IoT) paradigm proposes the interconnection of physical devices through networks that allow for sharing data, and for controlling their capabilities in real time. On the other hand, a temperature sensor was added to detect overheating and then prevent the current from flowing [26]. For mobile applications, the development of this system uses web service technology, building an Application Programming Interface (API) as a communication bridge between the mobile application and the IoT-based virus secure packet receipt box.

Communication

Internet of Things Ultraviolet Sterilizer Receiver Box and mobile application run successfully according to the design. Electronic devices as the basis for IoT data processing can be placed in a box and function properly with tests carried out with sensor detection test scenarios and access to application data services.

Three parts of the Internet of Things Ultraviolet Sterilizer Receiver Box work in unison by combining box mechanism, electrical device, and mobile application in an integrated manner.

The public can use the Internet of Things Ultraviolet Sterilizer Receiver Box to secure packages from viruses. Iteration is also needed to observe the use of the system so that improvements can be made to system deficiencies. The innovation is expected to answer the customer's need in keeping homes safe from virus particles. The research produces a stable and steady Internet of Things Ultraviolet Sterilizer Receiver Box product.

CONCLUSION

Internet of Things Ultraviolet Sterilizer Receiver Box can help maintain public health by preventing the COVID-19 virus with ultraviolet sterilization, and supporting a modern lifestyle to not have worry about delivery package. This innovative research is a small contribution that can be made to reduce the risk of transmission of the COVID-19 virus and other germs in the process of delivering essential goods to consumers, especially those through online purchases, namely those using delivery services.

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