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Design and Modeling of IoT IR Thermal Temperature Screening and UV Disinfection Sterilization System for Commercial Application using Blockchain Technology

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Abstract— **The increasing spread of the coronavirus across countries and with no sight of vaccine uncovered soon has prompted affected countries to impose strict containment measures. In view to ease the enormous strain on health systems; disinfection, decontamination, contact tracking, and isolation are a few health protocols that are to be observed by companies that resumed their activities to protect their employees from being infected. Hence, against a backdrop of heightened uncertainty, this project leverages on the advancement of technology to design and built a smart Infrared thermal scanning with a camera (Thermovis-Mi-FRAHT-800). An Ultraviolet-C spectrum disinfection system and integration of blockchain technology for data sharing, managing health records, and access control. SketchUp used as a 3D design platform for this project. This system designed with a precautionary measure which includes 3 conditions to be met for the automated barrier to be open which include temperature measurement, disinfection, and sanitization processes. Overall, a person spends less than a minute in the walk-through path chamber as the process takes 20 to 25 seconds each. By this calculation, we assume that 2 people would be able to get disinfected within a minute which comes up to 120 people per hour. Thus, reducing the number of monitoring staffs in direct contact with the stakeholders with potential infection issues. It is envisaged that developing this conceptual design would be the cornerstone in adhering to control measure through appropriate infection control and modification using current and future technologies.**

Keywords—Coronavirus, healthcare system, IR thermal screening, UV- spectrum C, blockchain technique

I. INTRODUCTION (*HEADING 1*)

Coronavirus disease 2019 (COVID‑19) is an emerging disease that has created a global health crisis at an accelerated rate and causing a high mortality rate on its trail (Wiersinga, et al, 2020). In this relation, specifically ASEAN countries like Singapore, Indonesia, Philippines and Malaysia has stretched their health care systems as they continued to report more cases and fatalities due to COVID-19. In fact, the healthcare systems particularly in many developing countries are experiencing varying levels of strain amid rising infection rates. Overall, the spread of Covid-19 has revealed that the healthcare systems were not designed to deal with this crisis, which includes inadequate supplies of personal protective equipment for healthcare workers.

In view of such shortfalls as well as no visibility of any vaccine being discovered soon by the communities of scientist; many countries across the world has imposed some of the strictest coronavirus containment measures in their quest to fight against this devastating pandemic. This was viewed as imperative that although the spread of the coronavirus has been relatively slow in South and Southeast Asia, it has the potential to create devastating social, economic, and political crises that will leave deep scars.

As a result of drastic containment measures amid a worrying spike in coronavirus cases, majority of countries in the Asian region recently has successfully bent the curve of this spread and subsequently crafted strings of stringent standard operating procedures (SOPs) that are to be adhered in many premises of specific nature and commercial sectors. However, relying solely on this approach may not yield positive and yet encouraging outcomes. Thus, it is envisaged that affected countries deploy a more sustainable long-term battle plan to reduce the number of new infections to a sustainable level, thus nullifying the risk of a new wave of infections.

The devastating pandemic situation has given an insight in exploiting emerging technology to design and develop a monitoring system as part of a first-line protection measure. In this connection, this project has a two-prong approach; firstly, to design and build an infrared (IR) thermal temperature measurement system and non-contact Ultraviolet-C spectrum (UV-C) disinfection station. This system design is equipped with multiple cameras to capture multiple angle detection as well as multiple object detection at a time to make a fast and secure screening process at the entrance gate. Secondly, the use of blockchain technology

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due to the need for a highly accurate record of potential COVID-19 infections which includes identify and tracking those who are infected as well as their contacts who have been exposed and subsequently to connect to disparate systems for data sharing, managing health records and access control. Consequently, the overall initiative of this concept is to act as an early detection of symptoms associated to this virus among the community of the institution.

Hence, against a backdrop of heightened uncertainty, continuous efforts should be initiated for containment, including active surveillance, early detection, isolation and case management, contact tracing and prevention of onward spread of COVID-19 infection.

II. CORONAVIRUS -19 : BATTLES WITH TECHNOLOGY

The COVID-19 pandemic has spread widely around the globe because of an outbreak in Asia in Wuhan, Hubei, China. According to World Health Organisation (WHO), COVID-19 is a new strain of coronavirus that causes infectious disease which was first identified in January 2020 (Shereen, et al. 2020).

Evidence shows that the primary way novel coronavirus infects people is through close person-to-person contact, mainly through droplets generated by coughs and sneezes.

The virus appears to be transmitted primarily through large droplets and viral dynamics revealed that the incubation period of COVID-19 was assessed to be between 2 and 14 days. This means that if a person remains well 14 days after contact with someone with confirmed coronavirus, they have not been infected. However, according to (Shereen, et al. 2020), symptoms associated to this virus are dry cough, sore throat, difficulty in breathing, tiredness and fever which may be surface in 14 days after exposure to someone who has COVID-19 infection. In addition, it was revealed that two main routes by which people can spread COVID-19:

(i) Infection can be spread to people who are nearby (within 2 metres) such that droplets could be inhaled into the lungs.

(ii) It is also possible that someone may become infected by touching a surface, object or the hand of an infected person that has been contaminated with respiratory secretions and then touching their own mouth, nose, or eyes (such as touching door knob or shaking hands then touching own face)

Generally, these infections can cause more severe symptoms in people with weakened immune systems, older people, and those with long-term conditions like diabetes, cancer and chronic lung disease.

As the world races to find vaccines and cures for this disease; disinfection, decontamination and isolation are the few measures that are strongly echoed by WHO to defend against the spread of this virus and eventually defend human race from being infected. In view of this, many governments have strongly advocated its citizens to embrace proactive effort to protect themselves.

Although the situation in Malaysia is still manageable, however, not knowing how this crisis will unfold in long term also affects its economic, physical, and mental well-being of the people. The reason being the after-effect of this pandemic presents the greatest test as it tends to have deep impact on the way we perceive our surroundings, community and our everyday lives. Consequently, necessitates specific protections to be introduced as the disease still poses a threat through its flu-like symptoms which may cause serious medical implications and even death. Like other heavily affected countries, Malaysia continues to enforce strict public health and travel policies and closure of schools and non-essential businesses until middle of the year. In view of reducing the rate of the transmission of the virus, it is evident the ministry has enforce mitigation measures to reduce the risk of this infections among others for frequency hand washing with soap, application hand-sanitising with sanitisers, wear masks when outside homes as well as practising social/ physical distancing. In addition, digital channel and social platforms are highly relied to play significant role in reinforcing protective measure by means of communication of critical risk and event information to all communities and counter misinformation.

In this connection, countries spanning from South Korea to Malaysia and other countries around the world are using advances in technology to track the coronavirus outbreak as they race to stem its spread. The technologies employed aimed at identifying where infected people are and monitoring quarantines which include among others are usages of drones to monitor illegal or large gathering spots, CCTV surveillance of those under a 14-day quarantine, robotic system to disinfect designated areas in health care centres and digital barcodes on mobile apps that highlights the health status of individuals.

As body temperature has long been used as a natural indicator of diseases; initial temperature assessment screening to detect a potential person with abnormal temperature plays an important role in preventing the spread of Covid-19. As having, fever is one of the definitive symptoms of COVID-19 patients. In this context, temperature assessment screening via IR thermal camera systems are currently gaining popularity among many organizations as they try to do their very best to contribute to global containment and prevention efforts. This screening system has been effective in detecting people with above normal body temperature i.e. with fever. The system can scan and measure exactly the temperature of (fevered) individuals as it provides the strongest correlation between outside skin temperature and core body temperature (Kirimtat. et. al. 2020; Negied, 2014). In this relation, this IR thermal temperature screening scanner coupled with cameras is used to dominantly at control gates to monitor and screen entrance by individual. In fact, the use of this IR thermal screening system has been proposed as a non-invasive, fast, cost effective and fairly accurate means for screening of potential persons with excessive feverish symptoms. However, since this system is geared as an initial stage of screening assessment and in the event a high body temperature is identified by IR thermal scanner; the identified individual is to be isolated and additional evaluation should follow such as doctor evaluations, laboratory testing and observation.

It was highlighted by (Casini, et. al, 2019; Shereen, et al. 2020), that contamination forms as the prime source of transmission of pathogens associated with infectious disease and infections in each environment. Based on the available evidence, WHO continues to recommend airborne

precautions as Covid-19 is acknowledged to be transmitted via airborne mode from an infected patient. Consequently, it was imperative that a decontamination mechanism is deployed as an important component of a comprehensive strategy to control healthcare-associated infections. In this relation, an automated disinfection system forms as the much sought out device to mitigate Covid-19 as this contagious virus can use multiple paths to reach a new host.

At this juncture, advancement in UV-C (ultra violet spectrum C) led technology which is an area of the electromagnetic spectrum is a relatively new frontier for solid-state lighting and consequently, forms as the promising solution for purifying air and water and for inactivating microbes.

UV light base disinfection system shows a lot of promise and it is based on the wavelength of the light. The longest wavelengths are UV spectrum-A (315–400 nm) and UV spectrum-B (280–315 nm), which are however, have limited germ-killing ability because of immunity developed against these sources by viruses and bacteria. The third class of light is the UVC light (200–280 nm) is completely absorbed by our atmosphere and never reaches the surface of the earth. According to (Dana, 2020) research already shows that germicidal UV can effectively inactivate airborne microbes that transmit measles, tuberculosis and SARS-CoV-1, a close relative of the novel coronavirus.

As the UV-C is germicidal; it destroys the DNA of bacteria, viruses, and other microorganisms, preventing them from multiplying, repairing the damaged DNA, and causing infections and disease. In addition, instead of heavy reliance of other chemical sanitizer, this system will prevent health risk of chemical contamination of exposed human organs like eyes or lips.

Despite existence of misconceptions about UV's safety, a lack of public awareness and technical know-how; initial evidence (Dana, 2020) suggests that UV-C light forms as the most relevant for current disinfection technologies as it does not penetrate beyond the outer dead layer of skin cells or the liquid film on eyes in healthy people.

In wake of the spread of this deadly virus, manufacturers have produce varied type of UV disinfection mobile robots that can reach hard-to-access places, moves around the room autonomously, eliminating the need for manual repositioning within the health care infection treatment rooms vicinity. At this juncture, the question of airborne transmission gained new urgency as the virus is so new and different that it needs its own vaccine. The situation is further compounded as this pressing crisis is very unpredictable. Consequently, prompting WHO to advise people of all ages to take steps to protect themselves from the virus; thus, causing the demand for UV disinfection equipment outside hospitals to soar.

Advancement of innovations has resulted blockchain technology to gain a lot of attention and expected to revolutionize inventions specifically for industry players that handle vast data because of its merit such as data integrity, data quality, transparency, avoidance of fraud and manipulation, reducing corruption, and enhancing trust (Jiani Wu and Nguyen Khoi Tran, 2018; Batubara, Ubacht and Janssen, 2018). In fact, according to (Golosova and Ramanovs, 2018), this technology has found applications in different industries and use cases, such as identity management, dispute resolution, contract management, supply chain management, insurance and healthcare, to name a few.

The blockchain technology is basically a new and innovative way of documenting information on the internet. According to (Jiani Wu and Nguyen Khoi Tran, 2018; Golosova and Ramanovs, 2018), a blockchain is a chain of time-stamped blocks that contain an immutable record of data and is managed by a cluster of nodes not by any single authority. Every block of data is secured and linked to each other with cryptography principles. Each block in the blockchain comprises of data, timestamp, a hash of the block and a hash of the previous block. The data saved in a block depends on the type of blockchain. The hash part of the block acts as a fingerprint as it gives a unique identification to the blocks and the associated contents. As the transaction takes place, hash of a previous block is always added to the hash of a new block to maintain chronology and ensure that blocks are valid. A timestamp includes the time when the block was created to keep track of the creation and updating time of the block. The method significantly makes a new block to always point to the previous block. As such, alteration or modification of any block within the network would make all the blocks invalid in the blockchain.

Reliance on blockchain technology plays a dominant role in health and medical care segments for safekeeping vital information specifically, those infected patients with chronic diseases whose health records are shared and handled securely without any manipulation. In this context, it was indicated by (Angraal, Krumholz and Schulz, 2017; Saha, et al. 2019; Prokofieva and Miah, 2019) that blockchain is now considered as a general-purpose technology and solution which will not only protect data from being tampered but will also ensure that the data leakage is stopped. The reason being, in the event this information is shared and communicated via email or paper-base, there is time, speed, storage, and security issues which potentially subjected to cyber-attacks to get some patient's sensitive data. Thus, ability of the technology to preserve data and thus guarantee reliability.

Advancement in technology has pushed this mode to the next frontier of innovation which include reliance on cloud as well as to be used as a wearable device of the patient keeping his information and consequently, require scanning for the biometric signature for further data analysis. Thus, enabling of tracking the patients and their data. However, in the former, the block-chain technology resolves storing and managing data issues.

As more people infected and compelling evidence that up to 30% of people with Covid-19 are able to spread the virus without showing any symptoms, thus pose a practical question on how to effectively monitor and potentially mitigate this contiguous crisis in the event mobility control order (MCO) in many regions are eased. As a result, emerging and future technologies are highly dependent to provide innovative solutions to break the chain of transmission.

III. CONCEPTUAL DESIGN AND FRAMEWORK

This proposed design project consists of: (1) IR thermal camera, (2) UV-C disinfection system, (3) Control panel.

Setting up a modular, scalable, customizable access point that could be placed on college campuses, outside

workplaces and other settings for screening purposes are often the first physical point-of-contact between a safety personal and other stakeholders, bringing with them an inherent potential risk of transmission.

The walk-through path chamber does not have human control and is being operated with the help of ultrasonic sensors and microcontrollers. A walk-through path chamber is set-up with an IR thermal camera which will screen the temperature of the people walking into the chamber. The two thermal scanners will be connected to a PC. This camera would report the temperature of the person even before they enter the walk-through chamber.

In the second stage, the disinfection system of UV light will be activated. The pathway has an auto gate system as a barrier and the gate opens when a user passes through the screening stage. In this system the UV-C light will be turned when someone passes through the barrier gate. The camera unit will be integrated with I-pad as a feedback for the user.

Usage of the hand sanitizer is critical to be used by the people passing though the chamber. As such a mechanical leg press hand sanitizer mechanism is integrated with the system to minimise contamination of the hand. The reason being hands touch many surfaces and can pick up viruses. Once contaminated, hands can transfer the virus to your eyes, nose or mouth. In addressing this concern, foot press pedal hand sanitizer system is infused and once pressed the bottle would dispense the sanitizer liquid. In response to this, a liquid sensor will detect the use sanitizer.

This smart system is designed with precautionary measure which include 3 conditions to be met for the barrier to be open:

(i) The temperature is meet the below the 37.5 degree Celsius.

(ii) The hand sanitizer must be used.

(iii) The pedal must be pressed.

Overall, a person spends less than a minute in the walk-through path chamber as the process take 20 to 25 seconds each. By this calculation, we assume that 2 people would be able to get disinfected within a minute which comes up to 120 people per hour.

Overall, the scope of the project are divided into 6 sections which include as follows:

1) Frame layout structure design.
2) UV disinfection sterilization.
3) IR thermal scanning with camera.
4) Blockchain-based data storage
5) Control and monitoring Station
6) Automated hand sanitizer application and verification

(1) Frame layout structure design.

The initial work of this system will focus on setting up a walk-through pathway chamber which holds on person per entry. The frame layout will be fabricated by the KWC Glass and Steel Works with the dimension is shown in Figure 2. The screening framework is size around 1500 millimeters in width and 4500 millimeters length and 2400 milimeters in height. It is placed carefully at a distance to address the bottlenecking situation that might happen as people wait, less than six feet apart, to be screened.

As such, walk-through screening booth/chamber provides as a precautionary solution that eliminates physical provider-potential infection carrier exposure that is simple to deploy for rapid screening operations. This indirectly allows for safe and efficient detection of visitors with abnormal temperature measurement. The overall structure of the system is as shown in Figure 1.

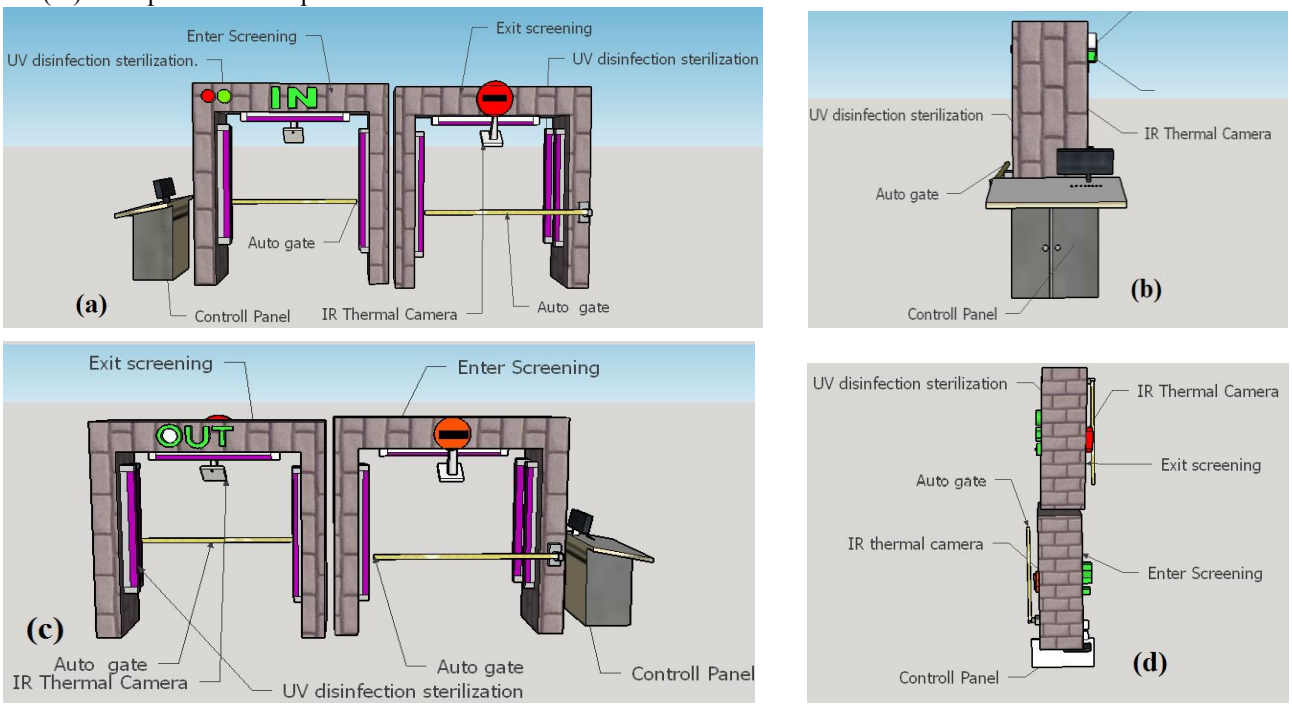

Figure 1.0. An automated gate with an automated IR thermal scanner and UV-C disinfection system. (a) Front view (b) Side view (c) Back view (d) Top view

(2) UV disinfection system.

At present there are many different designs for UV disinfection systems that is particularly effective at knocking out airborne pathogens. In this conceptual design, installing commercially available different frequency of ultraviolet would be even safer, even when it shines directly on people, which would also allow disinfection of surface. Consequently,

Figure 2.0 shows a Far-UV Sterilray (207–222 nm) which is different from UV-C disinfection options because it utilizes a different wavelength of the UV light spectrum.

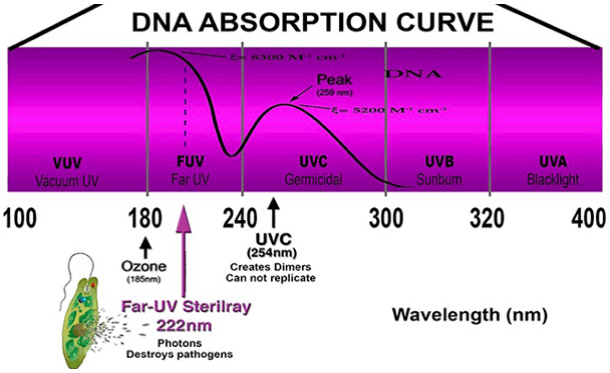

Figure 2.0. Far-UV Sterilray (207–222 nm)

Far-UV light has a shorter wavelength and higher photon energy than UV-C to provide the same disinfecting strength as UV-C without the dangerous side effects. Far-UV light can cause physical destruction of viral, bacterial, and fungal cells in a matter of seconds, much faster than UV-C lamps. Far-UV reliably eliminates any bacteria, viruses or fungi faster and disinfect more quickly than UV-C lamps, creating greater efficiency.

(3) Infra-red (IR) thermal scanning with camera

The IR thermal camera (Mi-Fraht-800) of interest would be the facial region since facial skin is thin, with blood vessels close to the skin surface. The product is from MDT Innovations Sdn Bhd. Those found to have a higher-than-normal facial skin temperature are assumed to have a higher-than-normal body core temperature and subjected to the second test using conventional clinical thermometers. Infrared temperature screening systems uses thermal imaging cameras and software to read skin surface temperature and calculate an estimated core body temperature. If that temperature is above a pre-set range, an alarm will sound to alert the elevated temperature.

Figure 3.0. IR thermal camera (Mi-Fraht-800)

(4) Control Station

The conceptual system is managed by a controller mechanism that operates the automated barrier gate. The controller system will detect the stipulated conditions which include read the results of the screening in this case temperature measurement check performed and hand sanitization performed check. An Omron WLCA12LDN limit switch is attached to a foot pushing pedal which is to give a signal to confirm a user applies the sanitizer, and then open or close the barrier gate. There are two (2) main types of controller are proposed for this project, Arduino or raspberry pi. There many reasonable price and many resources able to be found easily.

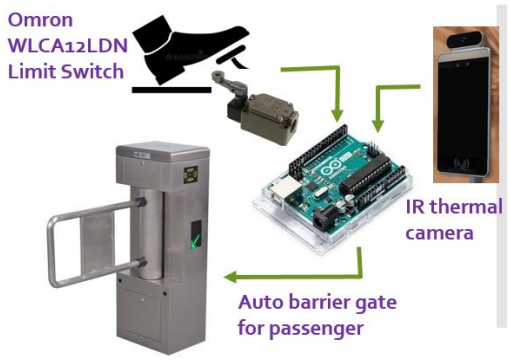

Figure 4.0. Control Station for SOP verification.

(5) Blockchain-based data storage

The block chain technique is deployed in the conceptual design is primarily for data sharing over the network and avoid dependency on one centralized computer. Figure 3 shows a blockchain-based network to store data. The proposed system model allows the development of the distributed data network in an efficient manner. All the personal computers (PCs) behaves as the edge nodes. All the PCs request from each PCs in the distrusted manner as a data storage for all the information. Each PC has its own crypto ID which is issued at the beginning of the set up. This crypto ID is used to establish trust between PCs in a communication network. All the PCs nodes comprises three (3) types of computational assets, which are computing, data storing and sensing.

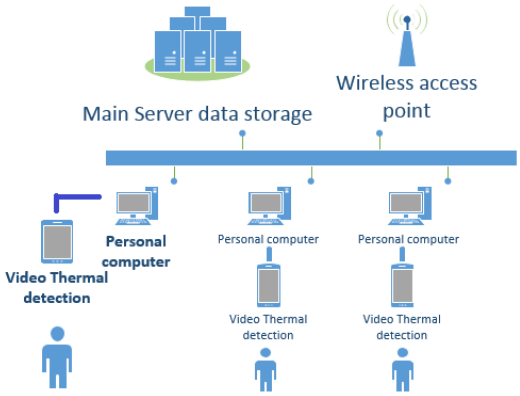

Figure 5.0. Blockchain technology

(6) Foot pushing pedal sanitizer application

There are many foot paddle sanitizer stand sanitizer holder sanitizer dispenser in the market. Get one unit and modify with an Omron WLCA12LDN limit switch. The switch is used to detect a user is pressed paddle during apply the sanitizer. A signal will send to controller and confirm the sanitizer is used.

Figure 6.0. Modification of Foot pushing pedal sanitizer

IV. CONCLUSION

In the current pandemic situation, a walk-through screening passage has increased accessibility and efficiency of the SOP directive by the Health Ministry. This proactive initiative is easy to apply in situations where employees/stakeholders visit on foot in a relatively small space. Thus, reducing the number of monitoring staffs in direct contact with the stakeholders with potential infection issue. It is envisaged that developing this conceptual design would be the cornerstone in adhering to control measure through appropriate infection control and modification using current and future technologies.

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