



JomMobileKey: Opening Business Sense During Covid19 Pandemic

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Abstract

Security remains a key issue in the hospitality industry mostly due to incidents of theft and crime as previously reported. This study aims to design a system that enables hotel guests to access hotel room without using a physical card. To promote high-security attributes, NFC (Near-field communication) technology as an access system by implementing applications containing emulated smart key for specific authentication access is used. The Host-Card Emulation HCE enables cost-effectiveness profit and initiates defense system in the pandemic era. The proposed system was evaluated by statistical and analytical analysis with hotel staff and managers in two different hotels located in Malaysia. The findings show the proposed system could replace physical cards, enhance security, and promote a contactless environment. More test cases at different locations are required to further validate the proposed system. The proposed system can be implemented in other industries in the future.

I. INTRODUCTION

Security is considered one of the most important elements and terms in the world for people [1]. Moreover, this term of security is an initial fulfilment in the hospitality industry [2] as it is important in other fields and industries.

Hospitality and the hotel industry are considered to be one of the leading contributors to the national economy [3] hotels became the significant major growth in industrial financial aid. Therefore, maintaining the hotel, and providing the best experience is a top priority for both the guests and employees in the location. It is known that most hotel operators or guests believe that there is a concerning amount of technology limitations and shortcomings in hotels around the globe [4], which is considered quite abnormal especially in this economy and the revolution future of Information Technology. One of the major important aspects in hotels that is responsible for security as well as management convenience is the hotel access points and their management [5]. Based on a survey study showed that 85% of hotel tenants or employees highly prefer using smartphones to lock/unlock doors in hotels [6] which is reasonable due to the significant numerous amounts of smartphones users.

Moreover, covid-19 has dramatically changed the hospitality industry to negative impact due to the increased number of cases which reduced the tourism to none, aside from the anxiety that occurs while visiting hotels due to the environmental nature of the indoor and crowded area. As covid-19 is air prone transmittable disease [7] it is a fact that the virus will stay on top of objects and is moved by physical touch. At the hotels, there are multiple door handles and

buttons to click on which increases the chances of getting infected.

NFC provides high innovative applications used in many fields and applications which emphasize secure levels of contactless operations, most NFC systems are composed of a tag reader which should have the ability to read any tag that could be passive or active to exchange data or the former. There are three types of operations that considered to be possible scenarios of applications which are read/write tags, peer-to-peer tags, and the card emulator [5]. In Figure 1, the specifications of each type are detailedly illustrated to give a simplified meaning.

In Malaysia, the hospitality industry is considered a major element that impacts the economy, however unfortunately based on the market survey conducted in 2021 research study as shown in Table 1, the use of mobile applications on smart doors has not yet been unimplemented.

Based on the market survey analysis done within this research Malaysia the major brands do provide door access systems, however, there is no NFC use in the system as most applications are only for Bluetooth techniques, moreover, the technologies used are mainly required interaction with the device which makes it a difficult choice to implement in hotels due to the covid-19 pandemic followed by the high price of the locks which ranges from RM900 to RM2000, hence making it an impossible solution to implement in hotels due to the multiple doors and many users.

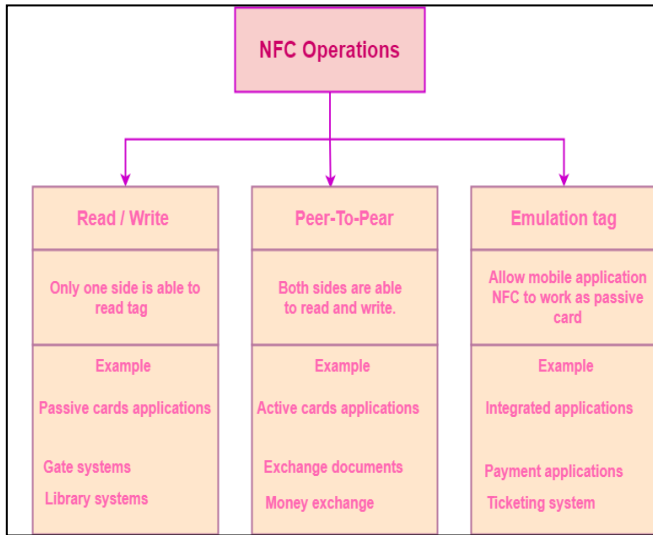


Figure 1: NFC Models

Table 1
Characteristics of modern smart door systems in Malaysia

Brand	Card	Bluetooth	Biometric	Pin	App	NFC app
Samsung	✓	✓		✓	✓	X
Yale		✓		✓	✓	X
Hafele		✓		✓	✓	X
Novaloc k	✓	✓	✓		✓	X

In hotels environments keeping a high-security level is an essential part of ranks and global acknowledgment, due to the high level of unauthorized access [1], that could cause negative damages to the reputation as well as the work algorithm, hence developing a security measurement of innovation that could secure hotels access points is fundamental, however, based on the current NFC methods used in the access points industry [2] it is considered quite difficult to implement the system in a hotel environment due to cost restrictions which are caused by the NFC limited to passive cards which requires high costs to generate to each user [3] especially in hotel environment as the number of cards would be a huge issue to maintain, furthermore it is prone to be lost or stolen from users which could cause a huge gap in the data registration as well as security followed by the costs to generate another pair.

The database in the NFC system [4] requires major complex algorithms to manage as it is stored in an external database that requires special access and complex measurement to do if a user dropped out or is no longer available, adding individuals could be quite bothersome to directly manage the, hence a mobile application with easily maintained database access to the management of the certain institution is highly efficient.

Convenience and sustainability are a must in hotel management however the use of smart door systems requires physical interaction and efforts to even during scanning the passive cards, which is considered unfitted for hotels especially in the door access points especially for employees that hold packages or disabled personals.

The current covid-19 situation which requires specific restrictions in socializing or interactions is highly monitored in hotels environment due to the high number of people and

overseas travelers therefore all smart lock doors that require touching as of biometric, passcode entering locks, and NFC cards that could be used by multiple users is highly contagious of the virus, therefore, damaging the reputation and ranking of the hotel. The research questions below in Table 2 illustrate the problem statement.

Table 2
Research Question

- Where can the hotel strengthen security by using intelligent access with smart doors in the hotel?
- What can the hotel optimize cost by using intelligent access with a smart door in the hotel?
- How can the hotel improve guest convenience by using intelligent access with smart doors in the hotel?
- How does the hotel mitigate Covid19 infection by using intelligent access with smart doors in the hotel?

The proposed system is a connectionless smart door system that uses the NFC technology as an active card to support hotel management through ensuring a high-level authentication system to help users to have an innovative way of navigating in the location with secure authenticity. The significance and benefits of this study are to achieve an innovation level of practices in hotels with affordable cost and increase awareness of covid-19 interaction in the hotel, due to the interaction-free technology of NFC which by default will strengthen trust within the user and application. NFC and the use of smartphones in developing an intelligent system based on a mobile application, which allow hotels to have a high-security level of access points. Table 3 shows the research objectives.

Table 3
Research Objectives

- To instill secured confidence by using intelligent access with smart doors in the hotel.
- To optimize existing available smartphone technology by using intelligent access with smart doors in the hotel.
- To provide a hassle-free contactless experience by using intelligent access with smart doors in the hotel.
- To innovate technology defense against Covid19 by using intelligent access with smart doors in the hotel.

Based on the research study corresponding to the problem statement, the proposed application is dedicated to having certain expectations to achieve the goals of the research and proposal Figure 2 Shows the model design of the Hypothesis considered in this study.

In the same concept, the research hypothesis was clarified into four different categories to dep up the process of the research as illustrated in Table 4.

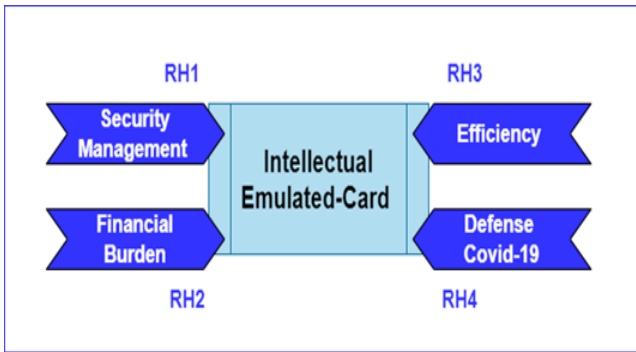


Figure 2: Hypothesis Model Design

Table 4
Research Hypothesis

- RH1: The matured secured communication of NFC smartphones will increase security levels by using intelligent access with smart doors in the hotel.
- RH2: Implementing existing user NFC smartphones will reduce the operation cost by using intelligent access with smart doors in the hotel.
- RH3: NFC smartphone contactless implementation instead of traditional methods will minimize users' actions and efforts by using intelligent access with smart doors in the hotel.
- RH4: Contactless individual NFC smartphone will eliminate Covid19 infection by using intelligent access with smart door in the hotel.

II. BACKGROUND STUDY

The industry of smart door systems has taken a few turns with different technologies which have their implementations, advantages, and limitations. In the world of security. Lately, multiple NFC applications and technologies were publicized to use by different industries like hospitals, smart homes, and labs.

The use of passive card NFC based implementation and applications has been in use throughout the years [2-4] which represents door traditional techniques that use an external system for databases and registry that requires extra energy consumption as it needs to be operated in a different device that by default results in a complicated databases system, besides being prone to high privacy and security attacks that violates the main purpose of a secure door system. Moreover, based on a 2020 SWIFT LANE study analysis card access systems [2] are vulnerable to a security concern of losing or misplacing the access card which leads to major risks to the building security.

The use of cards in access systems especially in hotels has multiple risks and disadvantages even if it was used for multiple applicants.

- Cards in hotels could be a disadvantage regards environmental issues which are becoming one of the most important aspects in hotels [2]. Cards are a natural resources consumption element that is created by wasting multiple environmental energy and resources, thus making it difficult for class hotels to be listed in green sustainable development top hotels.
- Card manufacturing requires huge costs for production and implementation, in addition, cards systems need to be continuously created as multiple cards could be lost

or damaged which needs to be replaced. To cut all these unnecessary costs and to raise the hotel industry's economic status smartphones applications are to be used [2] instead of the cards to manage costs and increase profit and hotel recourses.

- Based on a 2018 study analysis by hotel management magazine [2] key cards are becoming a troublesome and annoying object to carry by hotel guests and staff as it requires users to make pointless bothersome actions of looking for the card for long periods in front of the door where it is lost. Sometimes staff forgets to carry the key card with them during working hours therefore it objectifies as an obstacle for their work and accomplishment.
- In regards to cleanliness and hygiene issues which is considered the only and major important aspect in hotels especially during this covid-19 pandemic which requires a clean and hygiene environment to decrease and eliminate contagiously and transmitting the virus. However, it was published in an article study [3] that the most unhygienic and dirty object in hotels is the first thing the guest or staff holds when entering the hotel which is the key card. Alternatively using smartphones as an access object for hotels as of application and the use of NFC eliminated the unhygienic issue, therefore, significantly decreasing the covid-19 transmitting rate.

Based on the above statement and justifications using NFC within the application technology of a smartphone is further convenient by providing a hassle-free and high-end experience for hotel users. It was revealed that hotel guest expects using a smartphone as technology within the hotels' environment to innovate experience as frequently and as essential as needing a pillow in hotels. The novelty and uniqueness is NFC host-card emulation technology to create a mobile application that allows authentication in the hotel industry for the first time in Malaysia. Furthermore, the application is developed as an anti-contagious technology that is offered in all smartphones without additional costs to engage in creating a defence strategy against covid-19 transmission with a hassle-free contactless technology.

III. LITERATURE REVIEW

The hospitality industry has been struggling with managing the access points and the implementation of integrated innovation throughout the years, as there are many implementations and methodologies, to make affordable and innovative secure door systems that provide convenience as well as technology, thus multiple techniques are ranking from traditional magnetic door system and passcode door tags as smart home technologies to AI finger recognition door lock and traditional radio wave tags system [3]. In Table 5 multiple technologies of smart door systems are stated and thoroughly discussed and measured through the advantages and disadvantages of each technology, which allows the confirmation of the proposed system based on the alternative technology's shortcomings.

Table 5
Comparison of Different Access Management Techniques

Technology used	Advantages	Limitations
GSM module, SMS, face recognition [4].	Provides a real-time communication path between the owner and the system which allows users to get a notification through SMS or email regarding the situation. Has a higher security level of verification remotely.	Requires high costs of implementation and maintenance due to the use of the equipment as of camera and so on. Not suitable for any industry, only home security. SMS is considered not innovative and accurate as the message might be missed.
RFID, Arduino board, card verification [5].	Considered one of the low-cost options that provide security. The use of username and password verification. An integrated system of card scan or password.	The use of cards for the RFID connection isn't innovative enough and is considered costly and affects the environment. The database isn't accessed easily and checked; therefore, the user doesn't have an easy record of the system. Requires manual effort of users as they need to scan the card followed by pressing a button on the keypad.
Authentication of digits [6]	Considered a low-cost option to provide security due to the authentication passcode. Allow users to change the passcode and manage the security.	Requires manual interaction with the device which is not practical and innovative. Doesn't make use of any high-level security options like card verification.
IoT, Bluetooth, Arduino GSM [7].	The use of IoT allows more innovation through the internet. Provides remote control of the user to the smart door due to the camera installation and the IoT connection which the Bluetooth.	Requires high-cost implementation and maintenance. The key could be sent to any device if the username and password are correct. Limited to having internet connection.
Biometric, IoT [8].	Provide high security of double techniques of IoT to share data and fingerprint recognition. Implemented for hotel suits which have the feature of registering the user (tenant) fingerprint	Considered extremely costly due to the fingerprint implementation cost and the frequent need to maintain. The fingerprint usage requires user manual effort, furthermore, the interaction of user and system is discouraged especially under the covid-19

	at registration and deleting it later when leaving.	pandemic.
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In 2015 [9] a proposal using information hiding with NFC hardware specification to control access points was introduced with multiple advantages as the system provides two security measurements NFC and photo verification using information hiding, the proposal came with some limitations which don't correspond well with the technology now. Limitation of complicated algorithm and system which promotes less convenient for users, plus the tags need to be installed in each phone manually, not in a mobile application system [10].

A more innovative technology proposal using component analysis as the face recognition system instead of information hiding was introduced in 2016 [11], the proposal provided multiple benefits in relating to higher security due to featuring two high-level authentication technologies which are the NFC which is the NFC token as something the user has and the Face recognition system as something identified by the user, the NFC token in this proposal is a different item attached manually to the phone case or bag, the integration of two separate technologies in one system for control access considering the high cost to implement as it requires hardware equipment, furthermore, it doesn't have a mobile application for admin configurations, moreover, due to the use of NFC token, it is considered an environmental harming source and cost wastage of manufacturing the tokens.

Two different proposals in the field of campus or institutional areas with large graphical space were introduced in 2018 as separate proposals with different features mainly using NFC as the medium technology. The first proposal [12] is a control system for the NFC cards access method, hence the campus gates will be computed to authenticate and allow access by utilizing the NFC cards, in terms of costs and suitability the system is reasonable for a campus-like environment however the limitations of harming global environment due to sticking to the usual by using NFC cards which needs to be manufactured by striping environmental resources, in addition, the system doesn't provide a method to manage the records as everything needs to be done manually if removing a person is needed or adding one it would require complicated work and time. The second proposal [13] is a management key system for the door systems in universities as of labs hence it doesn't eliminate the use of traditional keys thus not innovating to the 4th industrial revolution, the traditional keys are specified as low-security mechanism due to being prone to lose.

In 2020 a dual system using the high-security level of two technologies of NFC and fingerprint identification was proposed [14], the paper provides a detailed scenario of authentication management systems, the proposal implements the technology for the 0 to 4 CM range which is quite bothersome for a crowded area, further-more, the existence of fingerprint authentication negatively affects the cost especially if the system is to be installed in a hotel or such, besides the methodology used requires physical interaction with the lock which is not encouraged especially as of the covid-19 situation.

The NFC technology has been actively used and inquired as an intellectual system to use in access management, however, there are multiple disadvantages shown through the NFC technology revolution even currently in 2021 there are

several limitations which is related to the shortage of mobile applications which are specifically developed to manage the access points, as the previous works highlight a more complex algorithm of data management to handle the withdrawal or renewal of users data, furthermore, the cost element is almost ignored due to the high level of dual security or integrated systems that requires high management levels, followed by the ignorance of the urgent need of contactless methods due to the covid-19

IV. DESIGN AND IMPLEMENTATION

In this study a 100% contactless solution of an intellectual smart door system specifically made for hotels in Malaysia which makes use of the innovative NFC technology, the application would manage both data and software maintenance cost-free and with a high level of convenience [15-17]. The mobile application system is designed in a way to remove any physical effort in opening the door because the user will be granted access through the NFC in their phones even if the device is in their pockets or so. As shown in Figure 3 the network of the project is classified as a prototype of the connection based on the implementation of development with the required objects.

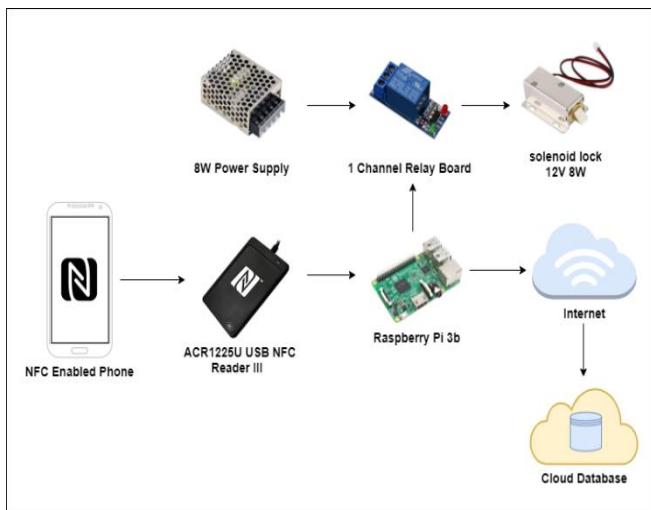


Figure 3: Diagram of the Device

Based on Figure 3 the developed application with the emulated NFC tag is to be scanned as a writer device into the specified NFC reader of ACR (contactless reader) that would read the data from the emulated card, the data from the reader will be sent to the raspberry pi memory to be verified in the firebase system. Directly after the verification if the access is granted then the raspberry pi will control the relay to be in high power which by default would control the lock to be open in a changeable time manner of a few seconds then the raspberry would close the relay by turning it low using GPIO. Oppositely if the access is denied the severe side will keep the relay off thus the lock won't open.

The raspberry pi 3 provides support of Linux OS which is highly required for this project for the connection to work between the NFC driver and the raspberry pi as it has shown a small interface of a computer which allows real-time communication of the system from the screen interface in the raspberry pi in contrast with the microcontroller, furthermore, in this project, the SD card is an important aspect for the database implementation and the installation of the driver

NFC, which makes the raspberry pi 3 is the most computable and needed for the project in contrast with the previous choice. Besides having the required means of ethernet connectivity which would be essentially needed in the coding process of the project.

The network diagram doesn't clearly show the electrical wiring and order of the power supply hence a second diagram is needed as a circuit diagram for the diagram electrical connection. Figure 4 shows the electrical circuit diagram of the connection.

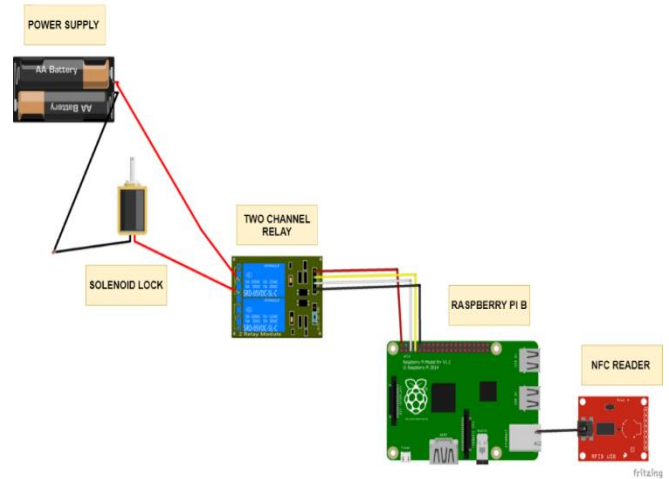


Figure 4: Circuit Diagram

The application allows users to register and log in using the Guest Booking ID, directly after the database verification of the Guest or Employee, the smartphone will emulate an NFC Tag as shown in Figure 5.



Figure 5: NFC Tag Emulated

NFC emulation of the home page in the application allows direct access and authentication even though the smartphone is closed as shown in Figure 6 of the real demonstration.

As the server-side grant the access of the relay control hence welcome message appears in the server-side terminal as shown in Figure 7.

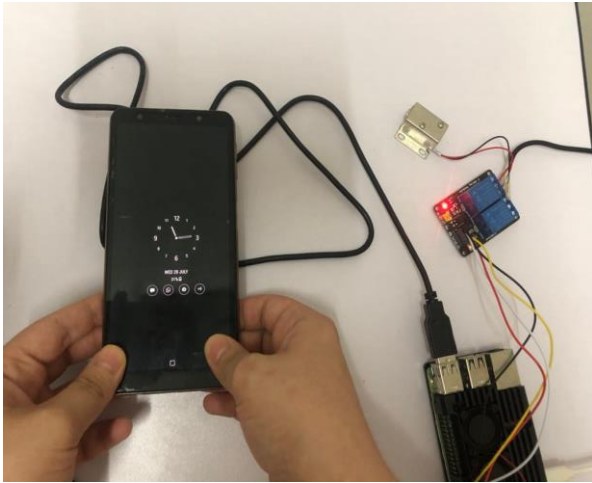


Figure 6: Prototype Solution

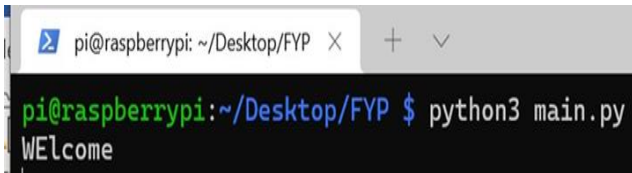


Figure 7: Access Granted

V. METHODOLOGY

The research applies the mixed-mode methodology study survey and interview [18-20]. The interview is conducted to gather the opinions of the individuals. Figure 8 shows the explanatory research design with an elaboration of each phase in the research study.

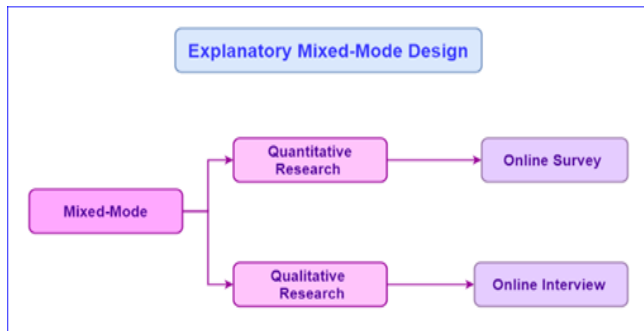


Figure 8: Evaluation Method

The population of the study needs to be further analyzed to examine the priciness of the research [21-22], therefore more than one location was chosen to conduct the research. Moreover, the participant was divided based on several aspects.

1. The age classification is an important element for an in-depth explanation, the age range will be divided into four groups essentially based on the expected guests to be in hotels.
2. Location specification: Two hotels located in Kuala Lumpur Malaysia are selected to participate in this pilot study.
 - Hotel A is a Three-Star hotel while Hotel B is an international chain Five-Star hotel

The second phase of the research methodology is the hypothesis testing of the Hypothesis model, the research has four different hypotheses to conduct testing on. The methodology used for testing will depend mainly on analyzing the responses based on the categories of sample

population utilizing the reliability test of Cronbach alpha value.

Cronbach alpha is a reliability test based on the likability of the survey analysis in the research, Table 6 shows the Cronbach alpha value based on a standardized analysis of the different hypotheses plus the average or final value.

Based on table 6 the Cronbach alpha value of each item dependently is ranging from 0.83-0.92 which relies on the high exceptional to be considered good-excellent value based on the globally recognized reliability testing. Yet the finalized value of all four-hypothesis managed together would be 0.91 which reasons with the excellent value of Cronbach alpha. If the Hypothesis of a certain item in the research happens to be below 0.70 it could be an indicator that the research is limited to questionable reliability or unreliable. As the index of this analysis has shown an average of 0.91 that is higher than 0.70 it indicates a high reliability of the research as excellence.

Table 6
Hypothesis Testing

Item Hypothesis	Cronbach Alpha	Final Cronbach Alpha
Authentication Management	0.85	0.91
Financial Burden	0.85	
Operational Efficiency	0.83	
Covid-19 Prevention	0.92	

VI. FINDINGS AND DISCUSSIONS

The survey is conducted in two hotels that are named Hotel A and Hotel B. There are 55% of the respondents from Hotel A and 45% of the respondents from Hotel B participated in the survey. Most of them are under the 21-30 age group (33%). Most of the respondents (44%) are hotel guests and are also under the category of the high-income group (53%).

Table 7 provides the perfect equalization of the individual percentage of each classification as of the allocation with a proper way as illustrated.

Table 7
Basic Demographic

Item	Variable	Percentage
1.	Location:	
	Hotel A	45%
	Hotel B	55%
2.	Age:	
	12-17	19%
	18-20	16%
	21-30	33%
	31-45	19%
	45-85	13%
3.	Income*	
	Low income	47%
	High income	53%

4.	Occupation:	
	Hotel employee	39%
	Guest	44%
	Others	17%

(*) Low income: below RM5000 and High income: above RM5000.

Challenges occurred regarding the privacy of study subjects, however, the primary survey analysis was analyzed as a whole entity to eliminate any confidential and privacy controversy in the study. The survey is pilot tested, and a reliability test is performed. The categories of sample population utilizing the reliability test of Cronbach alpha value. The value is 0.91 which shows the value is acceptable. Cronbach alpha is a reliability test based on the likability of the survey analysis in the research.

The impactful effect of the proposal is in terms of costs due to the availability of NFC technology in every smartphone in the market today, besides the NFC technology does not require high implementation costs. Figure 9 shows the different opinions regarding the implementation of the system in hotels in terms of persona cost saving.

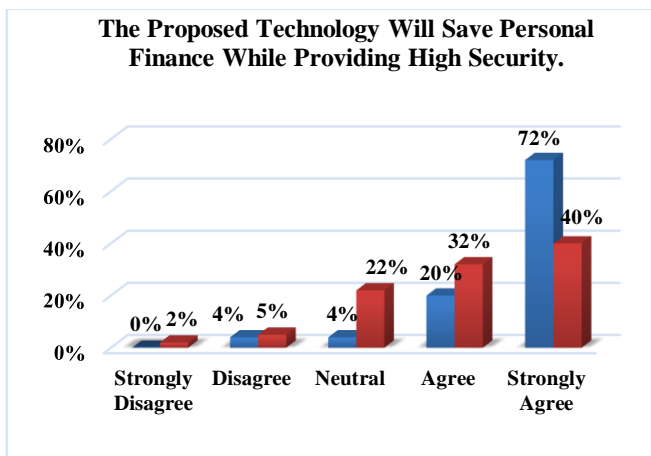


Figure 9: Primary Survey Analysis on Persona Cost Saving

An average of 95% of the participants from both locations has agreed with the statement regarding the cost benefits. Furthermore, Hotel A has shown a higher acceptance rate of the strongly agreed category with almost 72% higher than the 40% of Hotel B.

The prime feature of the NFC application is its effectiveness as it implements a contactless experience. In this analysis, the importance of the contactless feature is shown which reveals the high demand for such an innovation for the hotel in Figure 10.

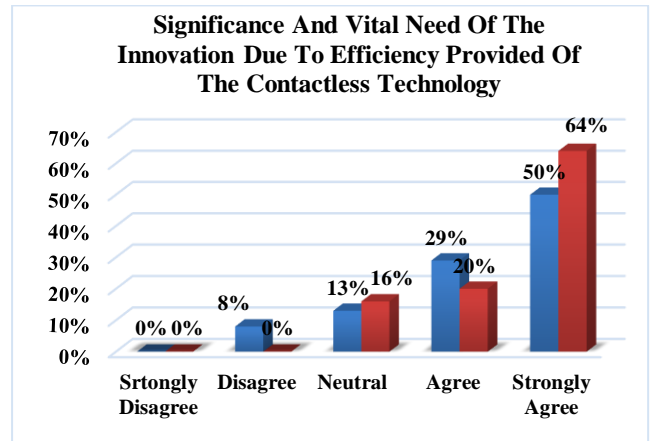


Figure 10: Analysis of the Importance of Contactless Feature

As seen total amount of agreement of 92% of the responses has expressed the dire need of the innovation by agreeing to the statement which involves the importance of the contactless feature, moreover the responses are directly related to the encouragement of using smartphone instead of the conventional methods of card keys and more. Notably, the responses from the four seasons hotel were remarkably larger in respect to the strong agreement to the innovation in compared to the other hotel.

Lastly, Figure 11 conveys the responses opinion in a more business aspect of branding in the context of the safety importance for the users from the covid-19.

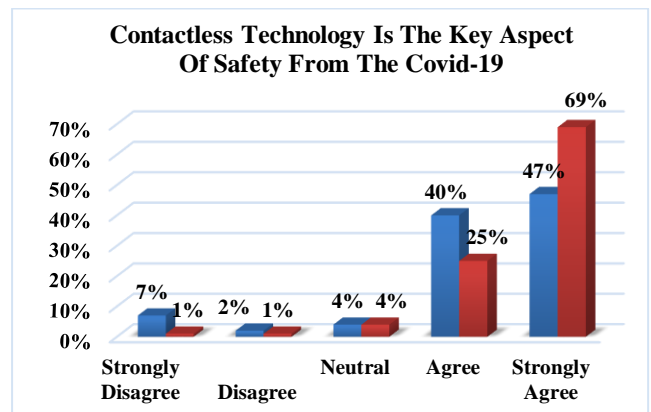


Figure 11: Analysis of Branding in The Context of The Safety

An impressive number of the total number from neutral to extreme agreement of 89% have shown support for the development to reduce transmission of the covid-19 virus. Moreover, notably, the positive responses from Hotel B are surpassing the ones from Hotel A, as 13% of the remaining 17% of disagreement comes from Hotel A.

In summary for the first aspect related to cost efficiency, it was revealed that the responses from Hotel A were 22% higher than Hotel B, in contrast, the responses regarding the branding trust of the application through the reduction of covid-19 transmission has been significantly higher as of the enthusiasm level in four seasons hotel with 16% difference with Hotel A.

There were notable peak results and differences between the two locations chosen, to summarize data analysis from both survey and interview the highest positive responses reported regarding cost-effectiveness and hotel human resource management were from Hotel A oppositely Hotel B had larger positive responses in regards the contactless

technology concerning the guest's convenience. Moreover, both locations had the same average of 95% of positive and encouraging comments given the competency and trust the application would provide for eliminating interaction and contagiousness of the covid-19. Figure 12 elaborates on the combined analysis from both interview and survey analysis to monitor the different rates.

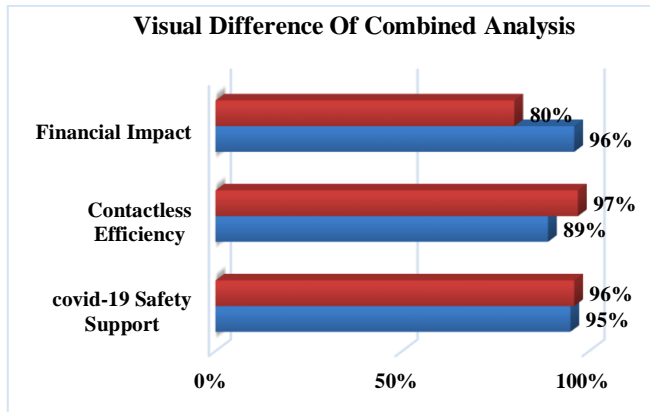


Figure 12: Final Analysis Comparison

The main reason for the difference is that Hotel A is a campus hotel which means that most of the guests are students with a closed budget, furthermore, the management is concentrated on implementing a secure system with suitable economical management. On the other hand, Hotel B has more sophisticated guests as a 5-star luxury hotel the competition is fiercely between the other hotels in the same location, therefore management would be directed into prioritization convenience which makes the cost not the priority here and to enhance the reputation. Moreover, both hotels have shown overstanding support on the contactless technology during the pandemic furtherly providing a safe environment for the student in Hotel A which is considered the priority during this time for the hotel management..

VII. CONCLUSION, LIMITATION AND FUTURE WORKS

In this research paper, an intellectual NFC door access application is developed for the first time in Malaysia using HCE innovation in the hotel industry by providing high authentication with cost-effectiveness for management and users. Yet with a significant convenient experience for users and the human resources field. Moreover, the advance has inspiring to eliminate any interactions which resulted in a notable improvement in reducing the contagious of covid-19 to none. Although the project could remarkably provide high effectiveness, highest safety measurement, and spectacular convenient experience. The evaluation study was limited to online long-distance testing due to the covid-19 lockdown, thus to obtain clearer and more accurate real-time results, the test should be perform at hotel location that would provide higher evaluation results. For the future, this technology can be expanded to more areas in need such as of medical industry and more. The project will be further developed into a larger industry that could permanently replace the physical ID card.

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