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The design of a model for providing information at local museums through mobile devices with Beacon technology

ABSTRACT

This research aimed 1) to study the information and information system of the museum, 2) to create a system for providing information within the museum via mobile applications, and 3) to assess the satisfaction of the users of information system within the museum via mobile devices by using Beacon technology. First, the data were collected from related documents and interview with experts, and the obtained data were then used for the design of a system and an application called MUCON which is Beacon technology for providing information within the museum. The designed information system and MUCON application were then tested and assessed by visitors at Ja Thawee Folk Museum in Thailand in terms of their satisfaction towards the performance of the information system and mobile application design, including additional comments and feedback by using questionnaire. The results showed that the system for providing information within the museum via mobile applications and MUCON application were successfully designed and created. Moreover, the satisfaction with the performance of the information system and mobile application design was also assessed and proved that they were suitable for use. Limitations of the study are discussed, and recommendations for further research are also made.

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Introduction

According to the current changes in terms of the development and driving global economy, Industry 4.0 has an important role in these changes. It focuses on bringing the world of manufacturing to connect with the network in the form of Internet of Things (IoT), which makes the production process connected with digital technology (Mourtzis, Milas & Vlachou, 2018).

Thailand has a policy of Thailand 4.0 as a guideline for national development by focusing on the use of digital technology innovation and creativity to develop and propel the country (The Secretariat of The Prime Minister, 2017). This is in line with the Industry 4.0 development framework that demonstrates the importance of information and communication technology (ICT) to drive economic and industrial development, especially the deal with Big Data which is one of the key drivers of Industry 4.0 (PwC, 2016; Salkin et al., 2018). Information system is another important factor that needs to be developed in order to provide complete information to receivers. The study of the needs, place, and time of receiving information should be conducted and developed so that the system can provide information appropriately according to the needs of receivers (Chingchuang, Ono & Watanabe, 2021; Chingchuang et al., 2020; Sofia & Mendes, 2019). Especially in the situation of the outbreak of Coronavirus Disease 2019 (COVID-19), people are now required to keep social distancing, and they are also necessary to search for information and/or study by themselves when they access information. As a result, this may cause confusion in finding information (Spring, 2021). Nowadays, there is the use of communication technology, providing and receiving information, or positioning through tracking devices in various organisations. It is essential that every organisation or

various agencies take these technological advancements into account and use them to provide information and communication services. These organisations include shopping malls, stores, airports, tourism industry, and museums (Casano et al., 2022; Đurdević et al., 2022; Katchwattana, 2020; Ko, Kim & Jwa, 2022; Komianos, 2022; Vo et al., 2021; Wattanacharoensil, 2019).

Technologies used in positioning are both for outdoor and indoor uses. For outdoor use, satellite system (e.g., Global Positioning System (GPS)) is mainly used. The function of GPS is positioning via satellite systems, which is suitable for outdoor use. As for indoor use, Line-of-sight (LOS) is more suitable. These technologies used for indoor positioning include Wi-Fi, ZigBee, Radio Frequency Identification (RFID), and Bluetooth Low Energy (BLE) which are the technologies that allow smartphones, tablets, and other mobile devices to position for indoor use effectively. It is important to note that BLE is well-known, and it is applied in many devices such as iBeacon technology (As et al., 2022; Dalkılıç et al., 2017).

As mentioned above regarding the importance of using communication technology to manage information systems, the technology called Beacon technology is another technology that can be applied in the development of information systems that are accessible to users effectively. It is an Internet of things (IoT) technology that can be used to connect to communication devices by transmitting a Bluetooth signal. It can be used both indoors and outdoors to determine the signal distribution point and location for receiving the signal in order to receive information as set (Kumkrua, Chokchaisri & Boonsomtob, 2020). In addition, the use of Beacon technology can reach all groups of people, including children, adults, and groups with physical disabilities such as blind people and deaf people so that they can use this application as an effective warning/alarm signal (Ruffa et al., 2015).

According to relevant research studies, it was found that many organisations have realized the importance and have used Beacon technology to develop information systems. For example, many airports have used this technology for tracking, positioning, and providing information systems to passengers (Katchwattana, 2020). Applying Beacon technology to educational institutions to benefit students helps students become more involved in learning (Zorić et al., 2019). Moreover, this technology can be used for positioning locations to promote tourism, provide interesting information, and create a comfortable experience for tourists (Ko, Kim & Jwa, 2022; Vo et al., 2021). Additionally, nowadays, museums have applied modern technology to keep up with the modern world and create interest, and Beacon technology is used as a navigation device that reduces confusion in route finding (Braidotti et al., 2021). It is a good substitute for public relations or location guidance. This will encourage visitors to do various activities on their own, known as self-service, to maintain social distancing and reduce unnecessary close contact with others (Casano et al., 2022; Komianos, 2022).

It can be said that the museum is a good source of learning with various information and is divided into many different exhibition areas. Properly organised information according to the visitor's needs will reduce the confusion of walking through the different areas in the museum. Also, the visitors can access/reach information of the whole building/area smoothly and effectively according to the objectives of the museum. Inside the museum building, Beacon technology can be applied/set and send information in terms of texts, images, and animation to the visitor's mobile devices according to the predetermined point. The researchers were therefore interested in conducting research on the design of information provision system and the application of modern technology in a museum via mobile devices. The researchers hope that the findings of this study will be useful to the relevant agencies and can be used as a guideline for future research for the most benefit.

The significance of the study

Regarding the expected benefits from this research, in addition to the expected success, the museum will be able to manage its information system for large numbers of visitors. It can also reduce the need for museum staff to encounter visitors. This can maintain social distancing in the era of COVID-19. It also reduces the problem of confusion among visitors within a large museum building in which there are a lot of details provided and be able to send alert messages/notification to reach all groups of museum visitors. In particular, people with physical disabilities such as blindness and deafness can use this communication device as an assistive device in the museum. Additionally, it can make museum visitors feel interested and fun with the design of information and enjoy provided information in the museum as well. Moreover, the findings of this research can be used as design guidelines for relevant agencies, further study, and information system development in the future.

Research objectives

1. To study the information and information system of the museum.

2. To create a system for providing information within the museum via mobile applications.

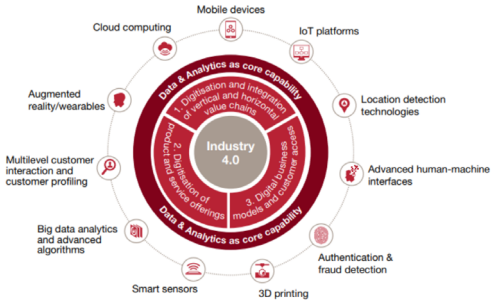
3. To assess the satisfaction of the users of information system within the museum via mobile devices by using Beacon technology.

Literature Review

The design of the information system in the museum through mobile devices by using Beacon technology can be divided into two main theoretical frameworks: 1) the Information Architecture Theory by taking time and place into account and providing information according to people's behavior and appropriateness (Fischer, 2012) and 2) the User Experience (UX) Theory and User Interface (UI) Theory to study the application design process, information display format, and appropriate use (Galitz, 2017; Treder, 2013) for museum visitors.

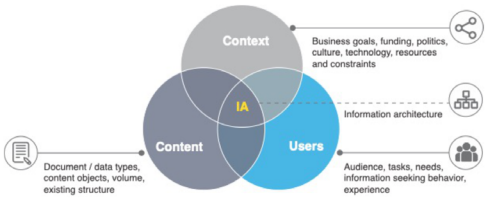
From the study of relevant research on the importance of managing the information system, it was found that the information system is crucial. The use of modern technology to keep up with the rapid changes in today's world can support the growth of the economy and society (Kutzner, Schoormann & Knackstedt, 2018), especially in the era of the epidemic of the Coronavirus (COVID-19) that makes everyone want fast and clear information (Gómez-de-Gabriel et al., 2022). Moreover, there is a matter of social distancing, so self-service in which service users can do every step of the process by themselves without touching or relying on others is required (Wang et al., 2022). Therefore, bringing technology that can provide information to meet the needs of the visitors or information receivers quickly and accurately is needed since it will be able to facilitate even more (Little, Pell & Blondel, n.d.).

For the policy of Industry 4.0, it focuses on the use of modern technology, especially communication technology used to develop industries in various forms (PwC, 2016; Salkin et al., 2018) as shown in Figure 1 below.



» **Figure 1:** *Industry 4.0 framework and contributing digital technologies (PwC, 2016)*

From Figure 1 above, it can be seen that the management of Big Data system, the application of mobile devices, and the Internet of Things (IoT) are applied to the development of various agencies around the world. Therefore, to make the design of information classification based on user needs (i.e., Information Architecture) efficient, three important elements that must be taken into account are context, content, and users (Gearon, 2022; Morville & Rosenfeld, 2007) as shown in Figure 2 below.

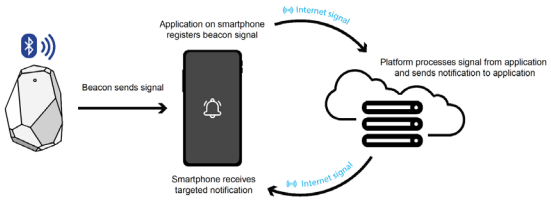


» **Figure 2:** *The infamous three circles of information architecture (adapted from Gearon (2022) and Morville & Rosenfeld (2007))*

Beacon technology

The Bluetooth Low Energy (BLE) Beacon is a small and lightweight device that is widely used in indoor positioning (Dhanyatha et al., 2019; Wong, She & Jeon, 2023). It is designed to automatically transmit BLE signals to receiver's mobile devices. These mobile devices are, for example, smartphone, tablet, or smartwatch of the user who is in the area where the Beacon signal can be reached. The signal will be set and sent out in the radius specified by the sender. It transmits at intervals of frequency and the number of times per second, depending on the developer. In this present study, BLE Beacon Version 4.0 was employed. Although it was introduced in 2009, and there have been later versions that have been developed and available in the market, it has been widely used till these days (Molina-Gil et al., 2022).

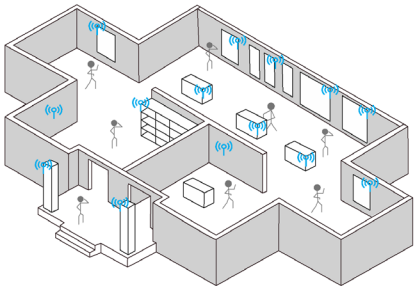
As for the activation process of Beacon in smartphones, tablets, and other devices, Beacon devices send a Bluetooth signal to the user's smartphone or device in the radius that the signal reaches. If the Bluetooth receiver on the user's smartphone is turned on, there will be a notification/information sent to the user immediately (Đurdević et al., 2022) as shown in Figure 3 below.



» **Figure 3:** *The Beacon activation process*

In addition, a number of studies have shown that the application of Beacon technology in sending messages can bring great user satisfaction. Although at present there is still not being applied in Thailand as much as it should be, it is of great interest to messaging developers across industries (Kumkrua, Chokchaisri & Boonsomtob, 2020).

Ruffa et al. (2015) conducted research on the use of Beacon technology in providing information and being as an assistive tool for blind people. This shows that, in addition to creating benefits for the general public, it can also be used to help visually impaired people as well. To understand more clearly, Figure 4 below shows the Beacon technology in action.



» **Figure 4:** *Beacon technology in action (Brooke, 2017)*

Research method

This research was divided into two phases.
For Phase 1, it was to study related information and find ways to develop the design of the information system.
For Phase 2, it was to design and create the information system at a local museum in Thailand and assess the satisfaction of the users of information system within the museum via mobile devices by using Beacon technology.

Participants

The participants of this study were divided into two groups. For Phase 1, the participants were experts and those who involved in information provision at local museums. They were chosen by purposive sampling. For Phase 2, the participants were 124 visitors at Ja Thawee Folk Museum which was the chosen museum in this study. All participants were Thai visitors, and they were chosen by convenience sampling. Regarding ethical issues, this research was reviewed and approved by the Institutional Review Board (IRB), (IRB No. P2-0424/2564). At every stage, the participants' names would remain confidential, and the results of this study were used for academic purposes only.

Research instruments

In this study, there were three research instruments used to collect data:

1) interview,
2) questionnaire, and
3) MUCON application.

The details of each research instrument will be discussed as follows.

Interview

In this study, interview was used to elicit information about general information about the museum, information system in the museum, the needs and problems of information system in the museum, ways to develop information system and the use of technology in the museum in the future, and other recommendations regarding information system in the museum. The interview was conducted with the participants in Phase 1. Table 1 below shows the interview questions used in this study.

Table 1
Interview questions

Part 1: General information about the museum	
Q1	What is the history of the museum, establishment, and its purposes?
Q2	What kind of the information does the museum provide?
Q3	What is displayed?
Q4	How many visitors per day are there?
Q5	During the day, when do a lot of visitors and fewer visitors come?
Q6	Who are the visitors and how old are they?
Part 2: Information system in the museum	
Q1	In providing information within the museum, what media is used to provide information to visitors, such as print media, LED media, digital media, or other modern technologies?
Q2	What are the criteria for the selection of media used to provide information to visitors at various areas in the museum?
Q3	In providing information to visitors, is there staff available to give advice and is there enough staff?
Q4	Are there any documents such as brochures or maps distributed within the museum to recommend places inside the museum?
Q5	In the COVID-19 era, what measures are there to provide complete information to visitors?
Part 2: The needs and problems of information system in the museum	
Q1	What are frequently asked questions from visitors?
Q2	Where are the important areas in the museum where visitors cannot notice or spend too little time there?
Q3	How should visitors walk inside the museum?
Q4	Where should visitors get the information / Where does it start and end in order to receive complete and continuous information?
Q5	Is there a placement plan and prioritized presentation of information?
Part 4: Ways to develop information system and the use of technology in the museum in the future.	
Part 5: Other recommendations regarding information system in the museum.	

Questionnaire

The 5-point Likert scale questionnaire was used as a research instrument to collect data regarding the satisfaction and the opinions of visitors who had tried using the museum's information system via their mobile devices using Beacon technology at Ja Thawee Folk Museum in Phitsanulok Province, Thailand. The questionnaire was divided into three sections: 1) respondent status, 2) satisfaction with the performance of the information system and mobile application design in terms of content and information provided inside the museum, the design of the application, and the usability of the information system inside the museum, and 3) comments and additional feedback on the information system and application design via mobile devices. The questionnaire was conducted with the participants in Phase 2. The details of the questionnaire are shown in Table 2 below.

Table 2

Questionnaire

Section 1: Respondent status, including gender, age, income, occupation, address, and frequency of visiting	
Section 2: Satisfaction with the performance of the information system and mobile application design	
1. Content and information provided inside the museum	
1.1	There is information provision within the museum covering all important areas.
1.2	There is information available to explain the details of the contents within the museum.
1.3	There is the provision of early warning information at an interesting point or at an area that cannot be easily noticed inside the museum.
1.4	Step-by-step information is provided, and there is a systematic pattern.
1.5	Useful information is provided, and it is easy to access the museum.
2. The design of the application	
2.1	The application has an easy-to-use format.
2.2	The application uses appropriate design colors.
2.3	The application uses suitable designed texts.
2.4	Graphic design and animation in the application are suitable.
3. Satisfaction with the usability of the information system inside the museum	
3.1	It can help to reduce confusion in searching for information within the museum.
3.2	It can provide complete information within the museum.
3.3	It can help to reduce time spent searching for various points within the museum by yourself.
3.4	It can help to create interest and encourage motivation to visit the museum.
Section 3: Comments and additional feedback on the information system and application design via mobile devices	

MUCON application

In this study, the researchers designed MUCON application which is Beacon technology and tested it. The details of this application will be discussed in the following sections.

Data collection procedure

The research procedure was divided into two phases. The details of each phase are discussed below.

Phase 1

It was to study related information and find ways to develop the design of the information system. First, related research studies and theories regarding the design of information system within museums through mobile devices and Beacon technology were studied. This aimed to set research objectives and create a framework for conducting this present research.

The data obtained were then analysed in order to be used to determine research objectives and create interview questions for experts' interviews before conducting a study in an actual museum. After that, a pilot study was conducted in order to test the feasibility and the development of the interview questions used in an actual study. It was conducted with two experts who involved in providing information at Wang Chan Museum and Textile Museum in Phitsanulok, Thailand. The suggestions provided could be categorised and summarised with the interview observation as follows. First, in general, the user groups were divided into three main groups: 1) a group of students aged 18-24 years, 2) working people aged 25-35 years, and 3) people aged over 35 years. Second, the data in terms of needs and problems of information provision were analysed, summarized, and used in creating interview questions in an actual study which included 1) general information about the museum, 2) information system in the museum, 3) the needs and problems of the information system in the museum, 4) ways to develop information system and the use of technology in the museum in the future, and 5) other recommendations regarding information system in the museum.

The complete interview questions, as shown in Table 1, were then employed with three experts in an actual study. The obtained data were analysed and used to create a guideline for developing the design of the information system and creating MUCON application and a questionnaire used to assess the satisfaction of visitors/users.

After that, a local museum that was used to set up a system to provide information via mobile devices using Beacon technology was chosen, and Beacon technology was then installed in that museum.

In an actual study, Ja Thawee Folk Museum in Phitsanulok Province, Thailand, was chosen. The selection criteria are as follows. It is a museum that presents locality and history of the province. Also, it is one of the most famous local museums in Thailand. Additionally, it is a museum with continuous visitors of more than 5,000 people per year and has been open for visitors for more than 10 years. The museum has staff members who give information about the museum and has more than five years of work experience. The pictures of Ja Thawee Folk Museum are shown in Figure 5 below.

» **Figure 5:** *Ja Thawee Folk Museum*

Phase 2

It was to design and create the information system at Ja Thawee Folk Museum and to assess the satisfaction of the users of information system within the museum via mobile devices by using Beacon technology.

The data and design guidelines obtained from Phase 1 were used to create an application called MUCON (Figures 8 and 15) as a prototype for use in testing and assessing information system and the satisfaction of museum visitors. This application was used and tested as the main information system within the museum.

Another pilot study was conducted in order to test and assess the satisfaction of users towards the MUCON application with three users. Also, the questionnaire used in the actual study was assessed through Index of Item – Objective Congruence (IOC) with three experts, and it met the criteria at 1.00. In addition, suggestions for the questionnaire development were also provided.

The obtained data were then used to develop the design and the complete questionnaire. After that, the MUCON application was set up at Ja Thawee Folk Museum. The details showing how to set up are discussed in the following section.

Furthermore, the questionnaire regarding the users' satisfaction was conducted with the 124 visitors at the museum in an actual study from August to October 2022. The data were then collected for further analysis.

Design of the experiment

As for the design and experimental process, the researchers created an application that allows visitors to receive information about the museum through text alerts to their mobile devices using Beacon technology installed at various points/areas inside the museum. The design and installation steps are as follows:

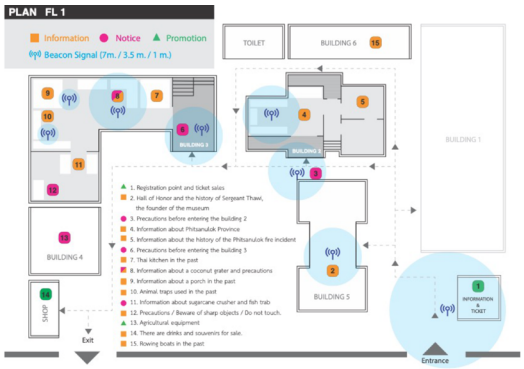
Step 1. Finding information regarding the museum in order to install the equipment.

At this stage, the researchers visited the museum in order to study the information, limitations, and environmental elements of the museum, including a form of providing information to visitors. The obtained details of the museum can be categorised as follows.

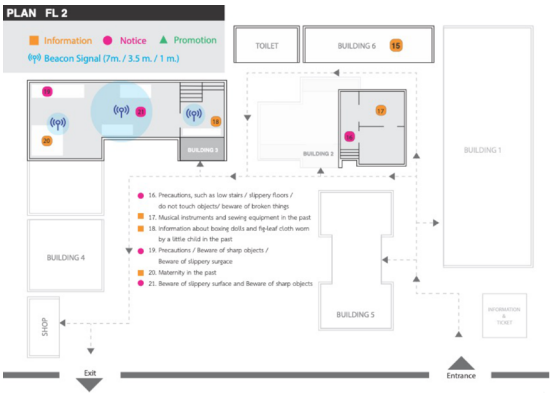
- The museum is a folk museum that presents the lifestyle and past history of the province. The form of information provision is to provide information through museum staff or some printed media.
- There are six separate buildings within the museum, with both one-storey buildings and two-storey buildings.
- Most of the buildings are made of wood and are original buildings that are over 40 years old.
- The information provided within the museum is divided into three categories: 1) detailed information about the history of the museum in different zones, 2) warning information about prohibition and precaution within the museum, and 3) information about sales advertisement.

Based on the above information, the researchers summarised the data and selected Beacon installation points to distribute signals around the museum. In this research, according to budget constraints, the researchers chose to install 11 signal distribution points (in blue circles), considering from the locations that visitors frequently asked staff and the areas that needed to be aware of as presented in Figures 6 and 7 below.

From Figures 6 and 7 below, the information presented in orange color is about the history and the way of life in the past of people in Phitsanulok Province. Pink color is prohibition and precaution inside the museum, green color is advertising information, and blue color is the installation and distribution points of Beacon technology. From the building plans below, the researchers chose to install all 11 signal transmission points by choosing from the areas that were most interesting for the visitors and at the point where the visitors had to be careful about accidents or prohibitions within the museum.



» **Figure 6:** *Building Plan of the 1st floor*



» **Figure 7:** *Building Plan of the 2nd floor*

At each point, signal transmission distance was chosen differently according to the area and the installation restrictions. From Figures 6 and 7, the blue circle shows the distance of signal distribution in various points. The researchers chose three distribution distances as follows: signal at 1 metre, 3.5 metres, and 7 metres. The signal distribution point at 1 metre was used for the areas where information provision was close to each other (i.e., No. 9,10,18, and 20). The 3.5-metre signal distribution point was used for the areas that were far from other signal distribution points, where information covered that area, and where there were no signals from other points to interfere (i.e., No. 2,3,4,6,8, and 21). The 7.5-metre signal distribution point was used for wide-open signal distribution points which were not close to the areas with other signal transmission points, such as a registration point and ticket sales before entering the museum (i.e., No. 1 in Figure 6). As for providing information within the museum, the researchers classified a type of information and its details as shown in Table 3 below.

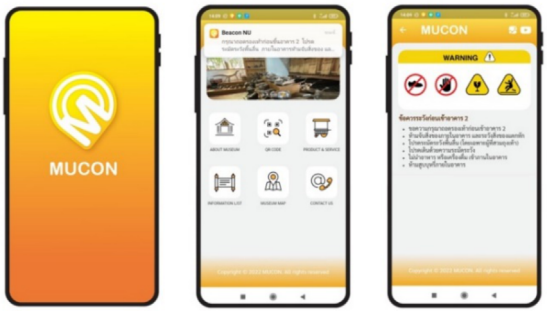
Step 2. Designing an application on mobile devices

Regarding the application design process, the researchers studied relevant documents and research in terms of the color theory used in designing icons, graphics, and arrangements to make it easy for users to use. This application is called MUCON (Figure 8). It should be noted that MUCON application in this present study support only Android system. The design of MUCON application will be discussed in great detail in the Result and Discussion section.

Table 3

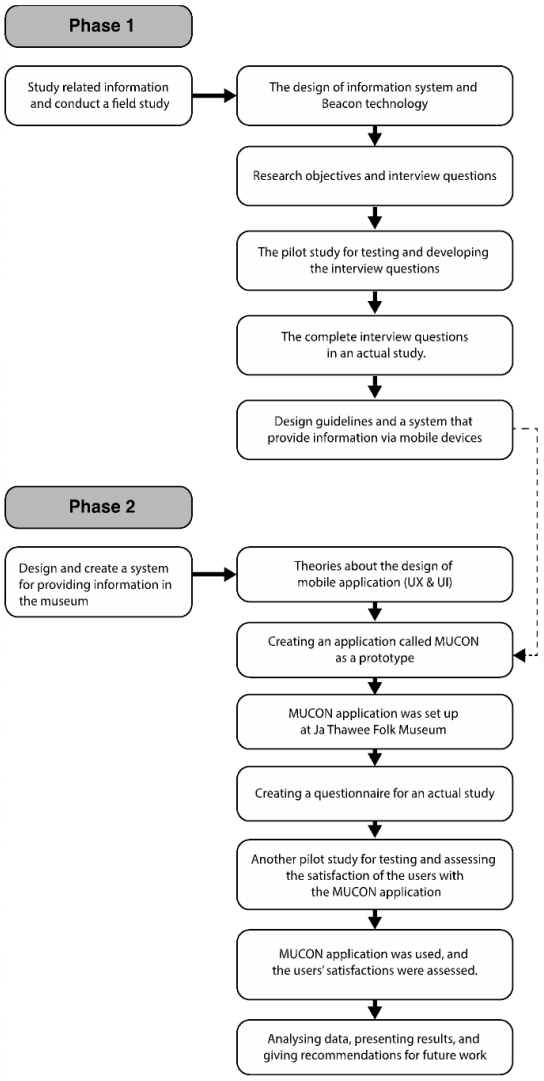
Type of information and its details

Type of information	Details
History	• Hall of Honor and the history of Ja (Sergeant) Thawee, the founder of the museum • Information about Phitsanulok Province • Information about the history of the Phitsanulok fire incident • Thai kitchen in the past • Cooking equipment in the past • Thai houses in the past • Animal traps used in the past • Equipment used for catching fish • Thai children's toys in the past • Agricultural equipment • Weapons in the past • Thai musical instruments • Maternity in the past
Prohibition and precaution	• Precautions before entering the building, such as taking off your shoes, not bringing flammable objects into the building, and not bringing food and drinks into the building • Beware of sharp objects • Beware of slippery surface • Beware of stairs and low ceilings • Do not touch / Do not hold • Do not enter • No smoking
Advertisement	• Registration point and ticket sales • Selling merchandise and souvenirs • Selling food and drinks • Learning promotion activities • A rotation of exhibitions in the museum



» **Figure 8:** *MUCON application*

To understand more clearly, the figure below shows the flow of the research structure in this present study.



» **Figure 9:** *The flow of the research structure*

Data analysis

In this study, since the data were divided according to the two phases of the study, data analysis was also divided into two phases. For Phase 1, the data were knowledge gained from studying related research studies and theories regarding the design of information system and interview data.

The obtained data were analysed by using content analysis. For Phase 2, the data were obtained from questionnaire regarding the satisfaction and the opinions of visitors who had tried using the museum's information system via their mobile devices using Beacon technology at Ja Thawee Folk Museum in Phitsanulok Province.

The data were analysed by using frequency, mean, standard deviation, t-test, f-test, and content analysis.

Results and discussion

The results and discussion of this research are presented according to the three research objectives of this study.

For Research Objective 1 aiming at studying the information and information system of the museum, based on related documents and the interview data, it was revealed that the local museums in this present study were the museums that aimed to reflect the identity and transfer the wisdom of the old lifestyle of Phitsanulok Province. Therefore, the main information provided in the local museums were the information about history, wisdom, way of life in the past of people in the community of Phitsanulok Province, the history of Thai textiles in the past, weapons used in battles in the old days, and biographies of famous people in the past. This information was displayed in the form of photos, home utensils, agricultural equipment, and printings providing information about the history of Phitsanulok Province in the past. They were exhibited for next generations to study.

As for the information system of the museums, it was found that mostly the information was provided through printings, such as maps of the museum, signs telling stories, and brochures that were distributed before entering the museum. Also, there were guides/museum staff who gave information and answered questions from visitors. However, there was only one museum in this area that officially presented the information via animation, video, lighting, light-emitting diode (LED) monitors, and projectors that had touch screens to provide information within the museum.

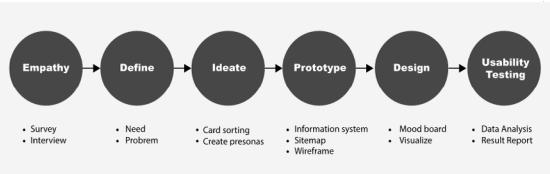
Interestingly, there were three main problems found from the interview data. That is, 1) there were not insufficient officials and guides who provided information and services, 2) the situation of the COVID-19 epidemic made most visitors need to keep distancing, and 3) although the brochures distributed before entering the museum provided information, the information was not detailed and was not grouped according to each particular group of visitors.

Therefore, the museums had a plan to improve and develop museums to meet the needs of information by using more advanced technologies to apply to the museum. Importantly, these technologies must not cause the original image and being the local museum to disappear. However, due to the budget constraint and the COVID-19 epidemic situation, these caused many plans and projects unable to continue. It was believed that setting a good information system could help to reduce the confusion that occurred within the museum and help the limited number of officials to provide information at various important areas where visitors often ask questions or some areas where visitors could not notice or overlook.

Moreover, a good information system could provide precaution notifications and prohibitions in the museum effectively. It is because using too many notification signs within the museum may make the image of the museum become not beautiful, untidy, and not suitable for the museum that looks local and traditional and obscure the displayed objects in the museum. Therefore, the use of media and technology to provide information that did not fade the image of the local museum was crucial.

For Research Objective 2 aiming at creating a system for providing information within the museum via mobile applications, the researchers designed and created the information system at Ja Thawee Folk Museum. This was conducted in Phase 2 of this study as discussed in the Data Collection Procedure section. The main result was the creation of MUCON application as shown below.

As for the application design, the researchers named the application by combining the words “Museum” and “Beacon”, resulting in the name “MUCON”. Regarding the design principles, the researchers drew mainly on User Experience (UX) design, User Interface (UI) design, and usability that affect emotions and feelings of users, for example, the choice of colors in the design, layouts, data locations, graphics, and buttons appearing on the screen for convenience and motivation to use (Khamchan & Kullimratchai, 2022; Kureerung et al., 2022; Mazumder & Das, 2014). The details of the design based on UX and UI are discussed below.



» **Figure 10:** *User Experience and User Interface design process (Adapted from Pacholczyk (2014) and Setiyani & Tjandra (2022))*

User Experience (UX)

The researchers studied the data obtained from Phase 1 in terms of user groups which were divided into three main groups: 1) a group of students aged 18-24 years, 2) working people aged 25-35 years, and 3) people aged over 35 years. The data were then analysed and summarised in terms of needs and problems of information provision. The researchers then designed Personas which is a profile model of a group of users by clearly specifying their age, occupation, needs, and problems in order to make it easier to find a solution in designing a system for providing information through a mobile application further (Adhitya, Andreswari & Alam, 2021). This aimed to define target groups in the design.

After that, the researchers brought the problems and recommendations to determine the direction in the design of information organisation, create the sitemap, and arrange the structure of the MUCON application. Next, it was created in the form of a wireframe for easy understanding and improvement in terms of functionality within the application. Also, this wireframe and design were developed, based on experts’ recommendations. This developed wireframe was then used for designing User Interface (UI) and creating the application for this present study since it allowed the researchers to see the placement and the design better as shown in Figure 11 below.

» **Figure 11:** *A wireframe of MUCON application*

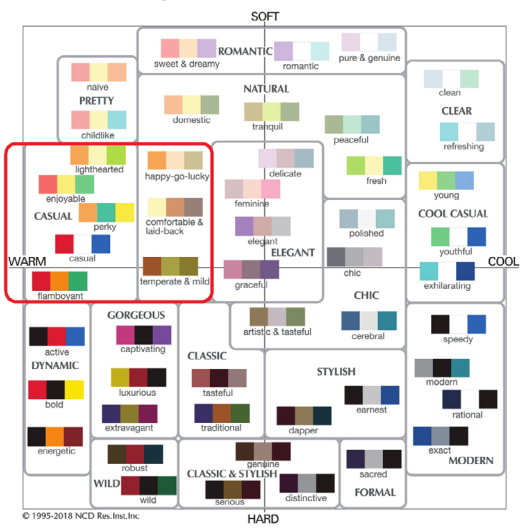
User Interface (UI)

Based on the result of designing the groups of Personas and creating a wireframe to set the direction in the design, the researchers studied and determined the color tone from the personality of Personas and analysed from various media of three main local museums in Phitsanulok Province. It was found that the color tones used were in the Casual and Natural groups based on the concept and theory of Shigennobu Kobayashi's Image Scale (Horiguchi & Iwamatsu, 2018; Kobayashi, 2009) which categorises colors that are suitable for personality as shown in Figure 12. The colors used in this study were the color groups suitable for teenagers, school students, university students, and general public. The colors used are lighthearted, enjoyable, mild, comfortable, friendly, and casual. These colors also communicate culture and nature.

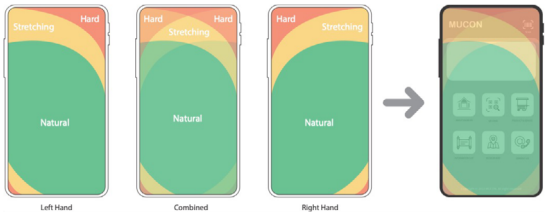
After the researchers determined the colors used in the design, the researchers also studied User Interface (UI) design principles, taking the nature of use into account by placing images and icons in positions that were easy to use with one hand, either left or right, or use with both hands together called “the thumb zone for mobile users” (Knight Design, 2020; Wijs, 2020) as shown in green color in Figure 13 below.

As for designing icons and graphics within the application, the researchers used the lines that looked simple and comfortable and brought some Thai shapes and uniqueness into the design.

This aimed to make it interesting and represent the local museums of Thailand within the application. Figures 14 and 15 show the design of main icons used in the application and the design of using an application to receive information within the museum.



» **Figure 12:** *Image scale for 3-color combinations (1995 to present) (Horiguchi & Iwamatsu, 2018)*



» **Figure 13:** *The thumb zone for mobile users (Knight Design, 2020)*

» **Figure 14:** *The design of main icons used in the application*

Regarding the use and information provision of MUCON application, after visitors successfully downloaded and installed the application, there would be a notification to start using it at the registration point before entering the museum as shown in No. 1 in Figure 15. Users can press to read details about the museum in order to understand before visiting by themselves. Moreover, within the museum, there would be a signal to send messages at various points periodically, such as information about displayed objects, history, prohibition and precaution, and advertisements in the museum.

In the application, researchers categorised information provision according to the needs of users and service providers within the museum. This makes the application easy to use and reduce confusion in use. It was divided into six menus, namely 1) About the museum, 2) QR code scan, 3) Products and services, 4) Information list, 5) Map, and 6) Contact staff. From these six menus, users can click to read information on pages as shown in No. 2 in Figure 15 which shows the detailed map of the 1st floor building of the museum. Within this page, users can zoom in or click to view details later.

The QR code scan function is for scanning to view information in the area where there is no signal. Visitors can scan to read details and can study the information by themselves through the use of this application as shown in No. 3 in Figure 15.

From Figure 15, No. 4 shows detailed information in various points with service information which will present pictures and VDO to provide complete information. Users can select from icons in order to link to different pages as needed. When selecting the picture, in No. 5, the picture will be enlarged and zoomed in to see details clearly. Additionally, when users want to watch a VDO with a lecture from the staff, they can click on the VDO icon to watch or listen as needed.

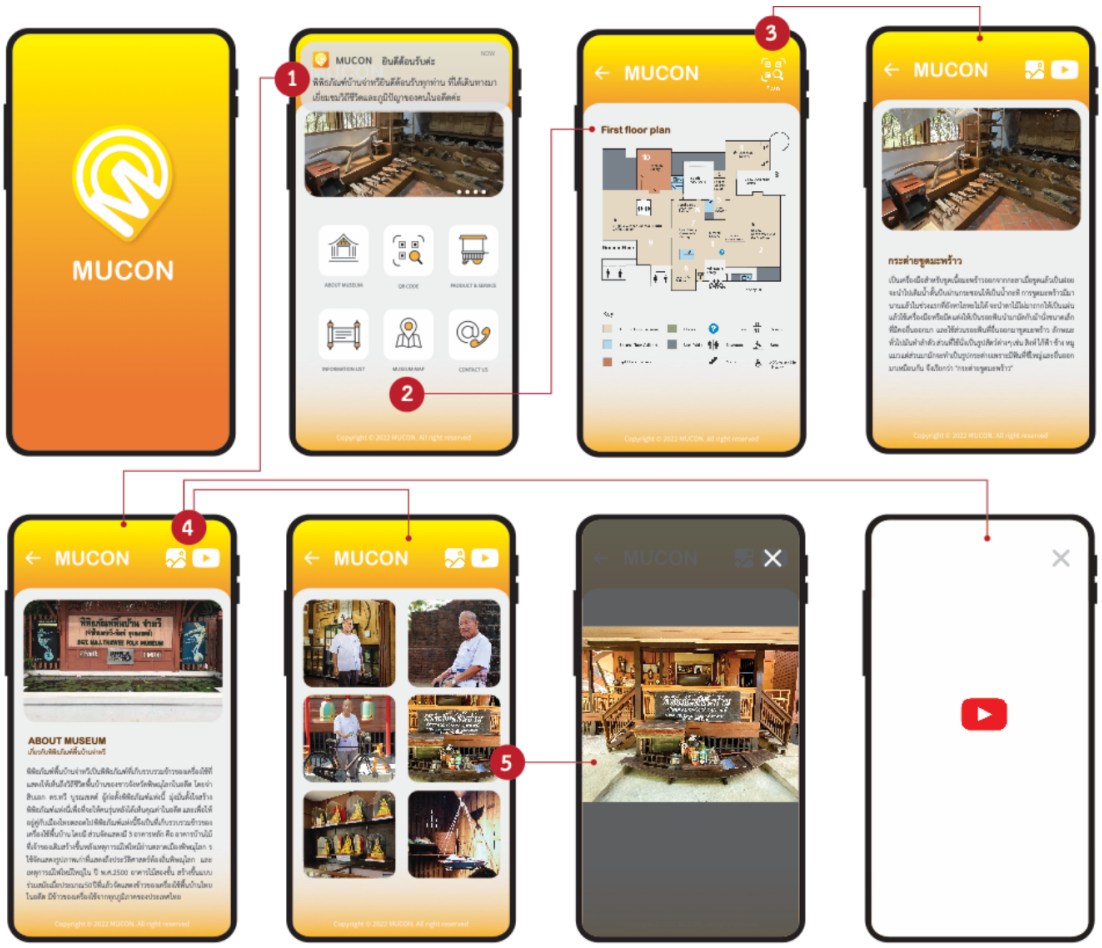
Usability

Based on a study of usability frameworks for user experience (UX) and user interface (UI), it was found that important factors for the usability of MUCON application included learnability, efficiency, memorability, errors, and satisfaction (Kureerung et al., 2022; Mazumder & Das, 2014).

As for learnability, this present study considered the easy-to-learn design. The layout of the position of use had a format that users were familiar and similar to other applications. There were only important and easy menus to use. Also, for the design of the application, the researchers focused on designing the color scheme, text, and icons that are all in the same way for easy understanding and continuous usage.

For efficiency, when using, there was uninterrupted operation and continuous use. Additionally, the user can search for information easily. It included content, images and animations. Also, it reduces designs or the use of unnecessary image files.

Regarding memorability, the user did not need to be trained to use since it was easy to remember its usage patterns. It was designed to have no complicated steps to use.



» **Figure 15:** *The design of using an application to receive information within the museum*

As for errors, there were a few errors in operation, or if an error occurred, the user must know what to do or quickly return to use.

In terms of satisfaction, as discussed in Phase 1 of this present study, there was a study on the related research studies and theories regarding the design of information system within museum through mobile devices to find suitable design guidelines for users' satisfaction.

For Research Objective 3 aiming at assessing the satisfaction of the users of information system within the museum via mobile devices by using Beacon technology, the results of satisfaction assessment can be divided into two parts. The first part is the satisfaction with the performance of the information system and mobile application design in terms of 1) the content and information provided inside the museum, 2) the design of the application, and 3) satisfaction with the usability of the information system inside the museum.

The second part is the comments and additional feedback on the information system and application design via mobile devices. The results are as follows.

1. The satisfaction with the performance of the information system and mobile application design

In terms of the content and information provided inside the museum, the overall satisfaction with this aspect was at a high level ($\bar{x}$ = 4.39, S.D. = 0.11). When looking at greater detail, it was found that the visitors thought that useful information was provided, and it was easy to access the museum ($\bar{x}$ = 4.58, S.D. = 0.61). As for the design of the application, the overall satisfaction was at a high level ($\bar{x}$ = 4.44, S.D. = 0.05). In greater detail, the results showed that the application used suitable designed texts ($\bar{x}$ = 4.52, S.D. = 0.63). Regarding satisfaction with the usability of the information system inside the museum, the overall satisfaction was at a high level ($\bar{x}$ = 4.48, S.D. = 0.05). In greater detail, it was found that the visitors thought it could help to create interest and encourage motivation to visit the museum ($\bar{x}$ = 4.52, S.D. = 0.65), and it could help to reduce time spent searching for various points within the museum by themselves ($\bar{x}$ = 4.51, S.D. = 0.66).

When looking at the differences and significance in use between men and women as well as age ranges, the results of satisfaction assessment with the perfor-

mance of the information system and mobile application design in terms of 1) content and information provided inside the museum, 2) the design of the application, and 3) the usability of the information system inside the museum are presented in Tables 4 and 5, respectively.

As Table 4 shows, there was no statistically significant difference in all aspects of satisfaction assessment between male and female visitors. Both male and female were satisfied with the performance of the information system and mobile application design.

From Table 5, it was revealed that there was no statistically significant difference in all aspects of satisfaction assessment among different age ranges of the visitors. All different age groups were satisfied with the performance of the information system and mobile application design in terms of 1) content and information provided inside the museum, 2) the design of the application, and 3) the usability of the information system inside the museum.

2. The comments and additional feedback on the information system and application design via mobile devices

Based on open-ended question questionnaire data, it can be concluded as follows.

- As for the use of MUCON application by some visitors, there was a delay in receiving the notification signal for up to 1-2 minutes. It is because each mobile phone can receive the signal at different speeds. In addition, each visitor's internet network is from different networks, and it also results in receiving notifications at

Table 4

The results of satisfaction assessment with the performance of the information system and mobile application design between male and female visitors

Satisfaction assessment	Gender				t	P (Sig.)
	Male		Female			
	$\bar{x}$	S.D.	$\bar{x}$	S.D.		
1. Content and information provided inside the museum						
There is information provision within the museum covering all important areas.	4.23	0.83	4.45	0.65	0.22	0.83
There is information available to explain the details of the contents within the museum.	4.23	0.81	4.27	0.59	1.37	0.18
There is the provision of early warning information at an interesting point or at an area that cannot be easily noticed inside the museum.	4.31	0.90	4.36	0.87	0.14	0.89
Step-by-step information is provided, and there is a systematic pattern.	4.33	0.77	4.40	0.64	0.57	0.57
Useful information is provided, and it is easy to access the museum.	4.59	0.69	4.57	0.57	-0.19	0.85
2. The design of the application						
The application has an easy-to-use format.	4.41	0.72	4.45	0.65	0.20	0.84
The application uses appropriate design colors.	4.28	0.72	4.46	0.65	1.22	0.23
The application uses suitable designed texts.	4.44	0.68	4.55	0.61	0.77	0.44
Graphic design and animation in the application are suitable.	4.28	0.76	4.45	0.67	1.09	0.28
3. Satisfaction with the usability of the information system inside the museum						
It can help to reduce confusion in searching for information within the museum.	4.36	0.78	4.46	0.55	0.66	0.51
It can provide complete information within the museum.	4.41	0.79	4.44	0.59	0.11	0.91
It can help to reduce time spent searching for various points within the museum by yourself.	4.51	0.79	4.51	0.61	-0.13	0.89
It can help to create interest and encourage motivation to visit the museum.	4.38	0.88	4.58	0.52	1.23	0.22

Note: p-value <0.05

Table 5

The results of satisfaction assessment with the performance of the information system and mobile application design among different age ranges

Satisfaction assessment	Age Ranges						f	P (Sig.)
	18 - 29 years		30 - 39 years		40 and over			
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.		
1. Content and information provided inside the museum								
There is information provision within the museum covering all important areas.	4.40	0.71	4.17	0.70	4.31	0.70	1.12	0.33
There is information available to explain the details of the contents within the museum.	4.46	0.65	4.17	0.76	4.31	0.60	1.19	0.15
There is the provision of early warning information at an interesting point or at an area that cannot be easily noticed inside the museum.	4.24	0.95	4.29	0.75	4.38	0.62	0.04	0.97
Step-by-step information is provided, and there is a systematic pattern.	4.38	0.69	4.33	0.70	4.44	0.63	0.07	0.94
Useful information is provided, and it is easy to access the museum.	4.59	0.61	4.52	0.59	4.60	0.63	0.13	0.88
2. The design of the application								
The application has an easy-to-use format.	4.49	0.69	4.46	0.51	4.19	0.83	0.11	0.89
The application uses appropriate design colors.	4.45	0.65	4.42	0.65	4.19	0.83	0.96	0.91
The application uses suitable designed texts.	4.57	0.63	4.50	0.51	4.25	0.77	0.20	0.82
Graphic design and animation in the application are suitable.	4.40	0.70	4.38	0.65	4.44	0.81	0.02	0.98
3. Satisfaction with the usability of the information system inside the museum								
It can help to reduce confusion in searching for information within the museum.	4.44	0.61	4.42	0.72	4.44	0.63	0.02	0.98
It can provide complete information within the museum.	4.44	0.63	4.46	0.78	4.38	0.62	0.02	0.98
It can help to reduce time spent searching for various points within the museum by yourself.	4.49	0.69	4.57	0.73	4.56	0.51	0.12	0.89
It can help to create interest and encourage motivation to visit the museum.	4.57	0.63	4.42	0.83	4.44	0.51	0.55	0.58

Note: p-value <0.05

different speeds as well. Therefore, the museum should provide the museum's own internet connection service and spread the signal that covers the whole area so that there would not be dead spots in the distribution of wireless fidelity (Wi-Fi) signals. Interestingly, there was a suggestion in that if the museum had a specific device for information provision, this would be more convenient. Besides, there should be a sign showing that it is the area where the signal is transmitted so that visitors would be able to find the transmission point more accurately and stop or slow down their walking speed to wait for information provision.

- For the use of MUCON application, it should add contents in the application to look more interesting, include more Thai identity to the design, and add functionality that has a voice narration at each point so that visitors do not have to read on the screen or hold the phone to watch all the time.
- Signal transmission points should be increased in order to provide more information in the museum. Moreover, various precaution notifications should be added.
- MUCON applications should support all systems, especially IOS systems.

Conclusion and future work

We studied the information and information system of the museum and successfully designed and created a system for providing information within the museum via mobile applications, including the application called MUCON. Moreover, the satisfaction with the perfor-

mance of the information system and mobile application design in the local museum in this present study was also assessed and proved that they were suitable for use.

Interestingly, based on the results of this study, each different mobile device affects the quality of receiving information, either slowly or quickly. Besides, the Bluetooth signal and the speed of the internet signal of each visitor's mobile device also has an effect on receiving information. Therefore, this could be solved by spreading more Wi-Fi signal of the museum and covers every area where the Beacon signal is distributed.

The design of an application that puts all information into the application only, not using a server to store all data, will consume too many resources of the visitor's mobile device. Thus, the museum may have to prepare mobile devices (e.g., smart phone or tablet) for visitors since the form of signal transmission will be through a Bluetooth signal from the Beacon technology only. This leads to effective and stable information provision. It can be said that the key factor of using MUCON application in this present study draws mainly on the internet since all information is stored on a server. When the Internet networks used by visitors are different, or the systems of mobile phones (i.e., Android or iPhone Operating System (IOS)) are different, this exactly affects the signal transmission from the server to the device and can be problematic. This makes it possible that the user will receive information slower than it should be.

For future research, the design of information provision through voice narration in various points/areas in the local museum should be conducted. This will definitely improve the quality of information provision in the museum since visitors do not need to read information through their mobile devices all the time while visiting the museum. Additionally, MUCON application in this present study supports only Android system. Thus, the future study on iPhone Operating System (IOS) system should be investigated.

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