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BUSINESS MODEL INNOVATION FOR IOT SERVICE

[1]ARUM PARK, [2]KYOUNG JUN LEE
[1]Research professor, Big Data Research Center, Kyung Hee University, South Korea
[2]Professor, School of Business, Kyung Hee University, South Korea
E-mail: [1]penellope007@khu.ac.kr, [2]klee@khu.ac.kr

ABSTRACT

This paper presents the benefits and challenges that companies can get by using the Internet of Things (IoT) technology. Researchers discovered business problems and designed and implemented service model to solve problems through action research. Action research methodology has five processes (diagnosing, action planning, action taking, evaluating, and specifying learning). In diagnosing stage and action planning, business problem and solution are derived (IoT-based six service models). In action taking, system is constructed on the real world space with IoT devices. In evaluation and specifying learning, the results of the study are analyzed. Especially, the four key elements of successful business model innovation (novelty, lock-in, complementarities, efficiency) are explained. In addition, we analyzed the business model and presented the benefits that stakeholders can gain as a result of business model innovation. The study contributes by providing knowledge to researchers and practitioners to study application of Internet of Things (IoT).

Keywords: *Internet of Things, Business Model Innovation, Action Research, System Development, Service Design*

1. INTRODUCTION

ABI estimates that at least 26 billion 'things' will connect to the Internet by 2020, and IoT is expected to be applied to a variety of industries, including agriculture, the automotive industry, ICT, mining, pharmaceuticals and health care, and energy industry [16]. This paper describes attempts to apply IoT technology to the culture and arts industry.

Companies that innovate business models using the IoT technology can acquire new business opportunities such as efficiency of management and operation, creation of new market, ease of market research using big data, and profit generation opportunity [16, 18]. The purpose of this paper is to propose IoT application in museums and to explore business opportunities such as operational efficiency, expansion of existing services and Customer Relationship Management etc.

IoT technology adoption and IoT technology-based scenarios have been the main topics of studies, however, there is a lack of research on how companies use IoT technology in practice. Also, there is still a paucity of studies on the social, behavioral, economic, and managerial aspects of the IoT [13].

Existing researches have focused mainly on the benefits of Internet of things. Many studies have been conducted in terms of improving quality of life or improving productivity and operational efficiency [3,4]. However, this study suggests not only the advantages but also the technical, economic, social and legal factors to be considered in utilizing the Internet of things.

The purpose of this study is as follows. (1) What kinds of business problems do small-scale museums have and how can IoT technology be used to solve them? (2) What are the benefits of museums, customers, and service users through IoT-based services? (3) What technical, economic and social issues exist in building and implementing IoT-based services?

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This paper consists of four parts. In literature review, the research trend on IoT and the necessity of business model innovation to utilize Internet of things are suggested. The second section explains the types of case studies and action research methodologies adopted to carry out this study. Third, IoT-based system design and construction are explained and the results are analyzed. Finally, implications from this paper are discussed in both academic and industrial aspects.

The main contribution of this paper is to discuss the benefits and challenges to provide companies with implications to reduce trial and error in the future. Also, while the existing IoT mainly focuses on the benefits of conceptual research and technology, the study can contribute to the diversity of research methodology and expansion of IoT-related business.

2. LITERATURE REVIEW

In this section, we will look at the main concepts, components, and functions of the Internet of Things, and explore how businesses should innovate their business models to acquire business opportunities through the IoT.

2.1 Components and Value of IoT

The Internet of Things has been realized on the basis of the rapid development of the information processing speed, the miniaturization of the devices, and the wireless network environment that can be connected to anywhere [21,22]. The definition of IoT differs among scholars. As shown in Table 1, IoT is commonly defined as the object that acts as the subject of producing, exchanging and analyzing data and interacting with other objects without human intervention.

Table 1: Definition of IoT

Authors	Definition
Haller et al, 2008	A world where physical objects are seamlessly integrated into the information network, and where the physical objects can become active participants in business process.
Sarma et al, 2009 [1]	"Things" from physical objects to virtual objects which represents as the identities with Internet connectivity
Zhang et al, 2014 [31]	A "Thing" on IoT that indicates a physical or virtual object which connects to the Internet and has the ability to communicate with human users or other objects
Fortino & Trunfio, 2014 [10]	IoT is emerging seen as a loosely coupled, decentralized system of cooperating Smart Objects (SOs).
Vermesan & Friess, 2014 [24]	IoT is a network of physical objects. The internet is not only a network of computers, but it has evolved into a network of device of all type and sizes, all communicating & sharing information based on stipulated protocols in order to achieve smart reorganizations, positioning, tracing, safe & control & even personal real time online monitoring , online upgrade, process control & administration
Krotov, 2017 [30]	IoT is defined here as a network comprised of various nodes belonging to the technological, physical, and broad socioeconomic environments

To accomplish this function, the Internet of Things consists of physical elements, smart elements, and connectivity elements. IoT-based products can provide four functions: monitoring, control, optimization, and autonomy [21,22]. As such, the Internet of Things is transforming products that consist only of existing physical elements [21,22]. In order to produce IoT-based products, enterprises need new capabilities to produce and utilize hardware, sensors, storage devices, and microprocessors. The Internet of Things will have a major impact on the production economy [18], as Internet in the past has had a large impact on the trading economy, which has led companies to innovate their existing business models.

2.2 Business Model Innovation

Although business model innovation is defined from various perspectives [22, 23], we can simply define business model innovation as the change in one or more of the components of a business model [2, 5, 12, 32]. This study is based

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on the definition of business model innovation proposed by Romero and Molina (2009), as shown in the following sentence [8].

"business models as definers of the value creation priorities in an organization should be continuously reviewed in response to actual and possible changes in the perceived market conditions and evolve the enterprise strategy as the business environment and customers' needs change."

Krotov (2017) proposed two ways to create value using the Internet of things. The first is sustaining value proposition with IoT to enhance existing products or services. This approach requires analyzing properties of existing objects and devising new ways for improving existing processes or transactions involving these objects. Second is a visionary approach. One should imagine a world in which every object is a part of a global, ubiquitous network [30].

Lee (2014) suggest the use of IoT to develop high-value-added products, expand existing services, respond to possible cannibalization, and implement PSS (Product Service System). It also suggests that companies can implement cost-effectively CRM (Customer Relationship Management) in the environment where automated CRM was difficult or impossible [18]. In this way, the Internet of Things can bring opportunities and risks to enterprises [20,23,31].

In particular, the Internet of Things is a destructive computing paradigm that can transform business processes [13]. Companies need to innovate their business models to survive in the market. Destructive technologies such as IoT are creating new business models and some companies and industries are in crisis.

Zott & Amit (2017) presented novelty, lock-in, complementarities, and efficiency as elements of successful business model innovation [6].

In this study, we will show how the museum innovate business model to adapt to changing customer needs and competitive environment, and discuss the results.

3. METHODOLOGY

Dul and Hak (2007) divided the types of case study methods into theory-oriented research and practice-oriented research according to its purpose [14]. [Figure 1] is a framework for determining the type of study of practice-oriented research. Practice-oriented case study is research is for providing knowledge to industrial practitioners.

Researchers define the problem or knowledge they want to study and set up a hypothesis and search for relevant theories to set hypotheses. After setting the hypothesis, we conduct the research to verify the hypothesis. In case of the hypothesis based on the theory that does not exist, we carry out the research to develop new hypothesis or proceed the descriptive research to describe the research problem.

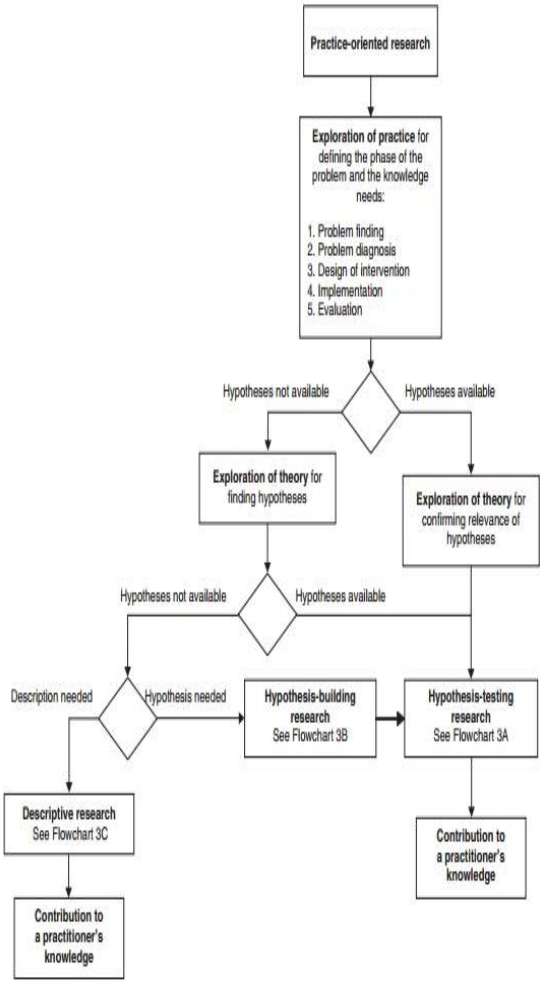

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Figure 1: Deciding on the type of practice-oriented research

This study is practice-oriented research to give knowledge to the practitioners by providing the benefits and concerns that the museum could gain by utilizing IoT. In the following paragraphs, we introduce action research methodology of this study, and introduce the system development process and the results.

In the field of information systems research, action research methodology is one of the important methodologies for system development [7, 26]. The action research methodology aims to pursue change and observe the results of the change to solve complex problems that are difficult to solve with other methods [26].

Action research's processes vary. Blum (1955) presents two diagnostic and therapeutic stages [9], but the most common action research's process is the five steps suggested by Susman and Evered (1978). (1) diagnosing, (2) action planning, (3) action taking, (4) evaluating and (5) specifying learning [11]. As shown in Figure 2, this study conducted action research in five stages. In the next section, we explain the research activities conducted at each stage.

Figure 2: Action research process

4. RESULTS

The case for action research is the Handok Museum of Medicine and Pharmacy, located in Suwon-gun, Chungcheongbuk-do, Korea. The museum was founded by Handok company in 1964 and adopted IoT technology for the purpose of providing new exhibition services for reopening in June 2015. The researchers started the project in February 2015 and completed the final test in July 2015, and the service is currently in use as of August 2019.

The main target customers of the Handok Museum of Medicine and Pharmacy are students from medical schools, pharmacies, and nursing schools, which mainly conduct group visits. In addition, it also runs educational programs for students and the general public, such as manufacturing medicinal drugs and health care products.

The following is an introduction to the research activities at each stage. In the Diagnosing phase, we found out the problems of a small sized museum through interviews and observations. In action planning stage, IoT-based service was designed to solve the problem. During the action taking stage, the process of constructing IoT system for the museum is presented. In the evaluating stage, interviews are conducted to figure out whether it satisfies needs of customer and whether the operational efficiency is improved. Finally, we discuss the advantages and disadvantages of IoT-based systems and service.

4.1 Diagnosing Phase

Hong et al. (2014) divides the process of exhibit planning into exhibition planning, exhibition design, installation of exhibition production, and analysis of exhibition results [28]. Table 2 explains the difficulties of Handok Museum of Medicine and Pharmacy. It has four exhibition halls on the first and second floors, and exhibits a variety of artifacts and treasures from pre-modern traditional medicine to western medicine. Many artifacts and exhibitions are regularly planned, and only two staff run

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educational programs and introduce artifacts to 200 to 300 group visitors a day.

Table 2: Analysis of current business process of the museum

Business process	Problems on employee side	Problems on visitor side
Exhibition Planning	• Insufficient workforce • Difficulties of new and various exhibition planning due to lack of budget	• Needs for new exhibition services • Obtaining and storing rich information
Exhibition Design		
Exhibit installation		
Analysis of exhibition results	• Difficulty in obtaining visitor information • Difficulty in Marketing due to lack of customer information	• Difficulty in obtaining information on future exhibitions

As mentioned above, the Handok Museum of Medicine and Pharmacy wanted to solve problems of lack of manpower and inefficiency of work process, and to digitize visitor information and use it for future marketing

4.2 Planning Action Phase

We planned six services to meet the museum's needs and mitigate its problems (see Table3). 'Foreign language service' was designed so that foreigners could gain information on the works when they visited. In addition, visitors can acquire exhibits information in the form of images, texts and audio through their own smartphones, and visitors can share it with social networks and send e-mails voluntarily to share information on the museum and work with other people (audio guide service, email service, SNS sharing service), which may encourage potential visitors to visit the museum. 'The Facebook Like service' functions as a communication channel for customer relationship management because the customer can receive information about future exhibitions by pressing the 'Like' button. Finally, 'web services' can be used to improve the quality of exhibition services by acquiring information such as which relics the customer prefers, how they move around, which social network service channels they prefer, visitor preferences, and viewing patterns.

Table 3: Proposed IoT based service model for museum

Service model	Scenario
1. Language service	• Visitors can acquire information on their works through their mobile phones in three languages: Korean, English and Chinese.
2. E-mail service	• The exhibit information can be transmitted via e-mail.
3. Audio guide service	• A guide service that provides not only text and image, but also audio information on the work.
4. SNS sharing	• Visitors can share their favorite works with other people through Facebook, Twitter, and KakaoStory. Through this, museum information and exhibition contents are spread online through visitors' SNS
5. Facebook Like	• When click 'Like' on the Facebook page, a communication channel is created between the museum and the visitor, and visitors can continue to subscribe to the exhibition information
6. Web service	• Through the web, museum managers can register and manage tags and beacons, create pages to provide their exhibit information to visitors, view data about which visitors

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	can check information such as which visitors are interested in, comments on the exhibits, and favorite SNS channels of visitors

4.3 Taking Action Phase

During the project period (2015), Android phone users were able to use NFC and beacon-based services, but iPhone users were able to use only beacon technology-based services, so we adopted both technologies to serve all of visitors. Another reason is that for the flexibility of the exhibition service range, NFC tags and beacon technology, which are easily removable, have been selected.

Figure 3 shows the architecture for providing services. The user receives the beacon signal or touch the tag through his / her smart phone to receive the exhibit information.

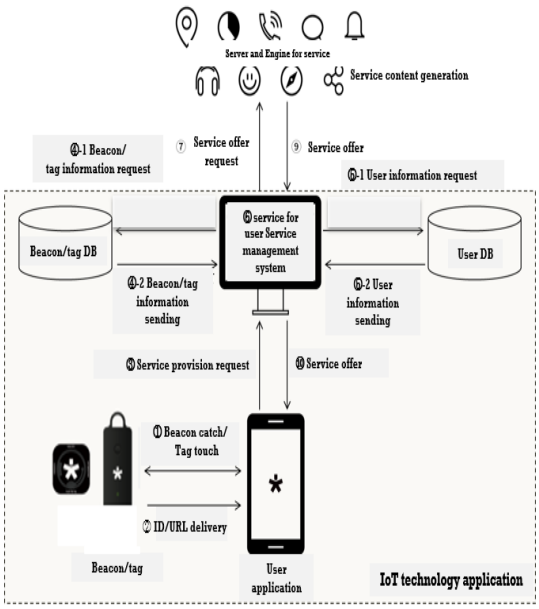

Figure 3: IoT-based system architecture

Figure 4 shows user interface of mobile application (for visitor) and web service (for museum manager) for the six services.

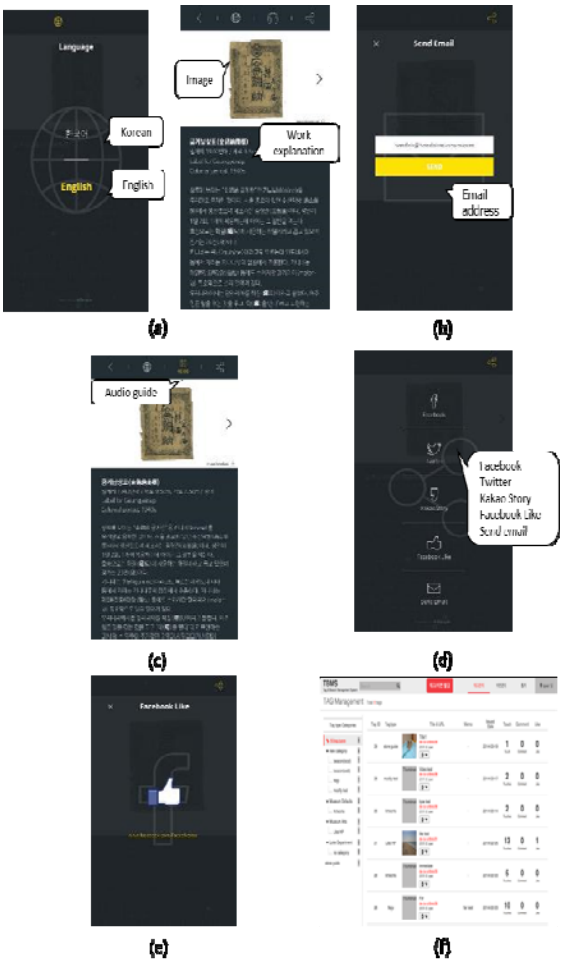

Figure 4: IoT-based service user interface: (a) language;(b) email;(c) audio guide ;(d) SNS sharing;(e) Facebook Like;(f) web service

Figure 5 shows NFC and beacons installed in the exhibition rooms on the first and second floors. Totally forty-four NFC tas and fifty-eight beacons were installed. As the visitor moves, the artifact information is automatically displayed on the screen of their smartphone (in case of beacon), so that the visitors can be acquired exhibit information more conveniently without paper based pamphlet.

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Figure 5 Installation of hardware:(a) NFC; (b)beacon

4.4 Evaluation Phase

After the final test in September 2015, we conducted in-depth interviews with 10 users and two museum employees. Based on the interviews, we figure out the benefits of IoT-based exhibition service that related stakeholders can obtain (see table 4). Table 5 presents three issues (technical, economic, social and legal).

In-depth interview was carried out according to five research procedures. In the first stage, literatures on NFC and beacon-based IoT services were reviewed, questionnaires were developed, and two researchers carried out cross-validation of questionnaires to secure content validity.

In the second stage, we discussed with museum staff to get their schedules and group visitor schedules for college students and adult visitors for in-depth interview. In the third stage, we conducted in-depth interviews with directors and curators of museum on the benefits and disadvantages of the IoT-based service. After the service description to them, college students and adults used the service from the first to second floors and they were filmed. Then, each in-depth interview was conducted for 30 minutes. One researcher asked questions and asking opinions based on the prepared questionnaires. The other researcher recorded it. At fourth stage, only the content related to the research subject was classified. In this process, there was a possibility that the bias of the researcher can be reflected. Therefore, cross-validation was conducted to increase the reliability and validity of the research results. In the last five stages, the results of the study were summarized and an in-depth interview result report was prepared. We got a feedback to properly reflect opinions of the directors and curators.

The stakeholders of the museum exhibition service consist of museum employees who play the role of exhibition planning and management, visitors who watch the exhibition, and IoT service providers. Using the IoT service, museum employees can upload information about the work on the web instead of producing a paper-based brochure, and obtain information on visitors' preference on artifacts and the daily visit frequency, which have not been obtained in the past.

Visitors install mobile application to use exhibit services, and experience new exhibition service such as conveniently sharing and storing information on exhibits at any time. It also provides an opportunity for visitors to upload their opinion in SNS, and museums can enjoy marketing effect. Finally, the service provider develops the exhibition service model, implements and maintains the IoT system. From the perspective of the business model, the value of the IoT based service is changed or improved, and the range of participating stakeholders for the museum are expanded and the role of each participant is changed. This means changes in business processes and changes in the profit model. Successful four elements of a business model innovation which are 'novelty, lock-in, complementarities, and efficiency' have been examined [6]. We analyzed the IoT service by the four factors.

(a) novelty: obtaining exhibit information conveniently on visitor' smartphone without lending docent service or dedicated device, providing exhibit information automatically according to user's location (for iPhone users),
(b) lock-in: continuous communication through marketing channels (Social Networking Service) with visitors
(c) complementarities: uploading comments on exhibits, share and store information on exhibits
(d) efficiency: Simplifying business process by uploading and modifying exhibit information on the web instead of producing the pamphlet

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Table 4: Roles and improved benefits of stakeholders

Participants	Improved Benefits
Museum employee	• Overcoming the limitations of the exhibition service, which had depended on existing paper type brochure and docent service. • Providing new exhibition experience to visitors with multilingual service and SNS sharing service • Attracting potential visitors to museum through sharing SNS and emailing • SNS marketing through SNS sharing and Facebook Like • Data on visitor's tag touch and beacon catch is used for exhibition planning, exhibition promotion and marketing • Visitors' preference on exhibits from SNS comments is utilized as personalized marketing materials • Creating strong brand awareness • Leading IT technology by leading adoption of iBeacon and NFC technology
Visitor	• Ease to acquire and store exhibit information • Continuous communication after exhibition
Service providers	• Service fee from Museum

4.5 Specifying Learning Phase

Various researcher drew challenges and issues in implementing IoT-based services such as data management, data mining, privacy, security, chaos and privacy issues [13, 15]. In particular, privacy protection and quality of service are in a trade-off relationship. Service providers collect data to improve their quality of life and provide services based on them, but this often leads to privacy invasion [13].

Table 5 presents the technical, economic and social issues and knowledge gained from the application of NFC and beacon technology for museum services. From a technical point of view, beacons have signal interference problems due to the limitation of the wireless Bluetooth communications.

The exhibition rooms in The first and second floor of the Handok Museum of Medicine and Pharmacy are divided into exhibition themes. The beacon is installed according to the exhibition theme by the request of the museum. Although the signal receiving distance is set short in order to provide the exhibition information automatically according to visitor' position, there was a section where the signal overlaps. When the signal overlaps, the two kinds of exhibit information could be shown on visitor' screen at the same time.

Table 5: Issues and knowledge through service development and application

Issues	Implications
Technical	• The beacons were installed on every exhibition section. Although the recognition distance is set to be very short, two beacon signals sometimes could be simultaneously detected. This may cause unstable signal reception.
Economical	• Batteries must be replaced periodically. Installed beacons send signals seamlessly, which consumes a lot of battery power. For the exhibition information service of museum, battery-less beacons are appropriate. The museum will save manpower and time, thus reduce maintenance costs.
Social and legal	• Insufficient awareness on beacon based service: As shown in Figure 5, as the beacon is not visible to the visitor, so visitors may not be able to recognize how the service works even though the beacon-based service description is provided on the site of the museum.

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The economic issue is battery replacement. Though the beacon battery is assumed to lasts for about two years, but the battery lasts for a year in practice. In addition, if a function for battery charge check was not developed, the administrators had to identify the battery replacement time with the color marked on the beacon by themselves (see Figure 5). In business environments such as museums, battery-less beacons that do not require battery replacement have recently been developed, so using these beacons will be even more efficient for maintenance [33,34].

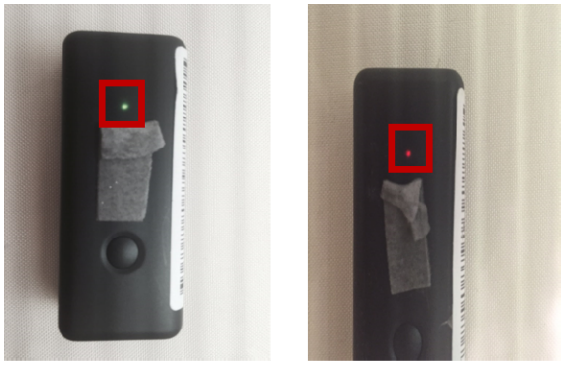

Figure 5: beacon battery issue: (a) charged battery(blue);(b) out-of battery (red)

Finally, social and legal issue. As shown in Figure 6, a guide to NFC and beacon-based services is provided. NFC users already have experience on NFC-based services in the market, and there are many users who have learned enough how to use them, even though they do not have experience. Because NFC tags are attached near artifacts, users easily learned it. However, beacon-users have not yet had experience beacon-based services. In addition, beacons are not visible to users. Therefore, users do not know when users receive the signal and gain the exhibit information. As a result, the authors propose smart button method based on this experience.

Figure 6: Service guide

Researchers applied the button-type beacon to the hospital space, event and convention space as Figure 7 [3, 4, 17]. Consequently, users intuitively push the buttons and recognized how the service works. Administrators no longer need to explain to users how services are provided. Administrators of museum should select types of beacon according to the characteristics of offline space or the level of recognition and experience of users on technology so that users can use the service intuitively and conveniently.

Figure 7: Button-based beacon

5. CONCLUSION AND DISCUSSION

This study is the result of constructing a system and planning a IoT based service to discover and solve business problems of museums. IoT technology offers a variety of benefits to business participants. Visitors can have a new exhibition experience that can gain the high quality of museum services and acquire, store, and spread information efficiently. Despite these positive aspects, many technical, economic and social issues arise when the system is operating. In order to solve

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problems such as signal interference, battery replacement, and difficulty in recognition of service usage, researchers suggested alternatives such as batteryless beacon and smart button type beacon for appropriate service design according to characteristics of space, user 's service experience level, and user' s characteristics.

We also analyzed the IoT-based museum business model based on four factors for successful business innovation.

This paper explains how IoT technology can be utilized in solving business problems. In addition, it contributes to the diffusion of IoT technology to the variety of industry by providing experience and knowledge to researchers and practitioners who want to apply these technologies.

In order to enhance the user experience of NFC and beacon service, it is necessary to conduct UX research. Also, although not covered in this study, the standards and procedures for users' privacy and security need to be discussed.

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Appendix: Interview protocol

Open interview protocol is to figure out benefits and challenges from IoT service and assess successful factors of Business Model Innovation by Amit &Zot.

Interviewer: Arum Park

Institution: Big data research center, Kyung Hee University

Duration: 6 hours/ 10 users and 2 museum employees

Date:2015.09

Data recording: Paper

Aim of interview: The aim of this interview is to analyze what is results of business models innovation based on successful factors of Business Model Innovation by Amit &Zot. what do the users and museum employee think about IoT based service? Consequently, what are positive and negative points of IoT service for small-sized museum?

Protocol:

1. Introduction of the study and museum, NFC and Beacon technology

2. Introduction of interviewee background

3. IoT exhibition service experience

4. Questions regarding IoT service

5. Further comments interesting for the study

6. End of interview

1. Introduction of the study

a) Short introduction about study and researcher.

b) Short introduction about Museum

c) Short introduction about NFC and beacon technology

2. Introduction of interviewee background

a) Please introduce yourself

3. IoT exhibition service experience (all first and second floor).

a) NFC user: NFC mode selection

b) Beacon user: application download, Bluetooth setting

4. Questions regarding IoT service

a) User

- whether he/she experience NFC and beacon
- What is the positive point when you use IoT service
- What is the negative point when you use IoT service

b) Museum employee

- purpose of IoT service adoption
- whether he/she experience NFC and beacon
- What is the positive point when you use IoT service
- What is the negative point when you use IoT service

5. Further comments on IoT service

6. End of interview