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A content service deployment plan for metaverse museum exhibitions—Centering on the combination of beacons and HMDs

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ABSTRACT

Today, methods of museum exhibition are rapidly changing. While focusing on visitors' museum experience, new display methods employ a variety of digital technologies to provide exhibition content in ways that allow visitors to better understand artifacts on display. However, the majority of such methods rely on one-way means of delivering information. The lack of interaction with visitors and the use of lighting that clearly separates real and virtual spaces have made museums inadequate as experiential spaces. To resolve those problems, this article suggests a plan to deploy content services for visitors' museum experiences by combining beacons and HMDs. This study establishes the concept of a service, which provides a virtual world experience by connecting a beacon installed in real space, that is, an exhibition room, to an HMD (head-mounted display). Furthermore, the service also incorporates a storytelling feature to diversify user experience by presenting the characteristics of and stories about artifacts. The service design will make both online and on-site museum experiences meaningful. Ultimately, this article presents the exhibition content thus created as Metaverse exhibition content made through an effective combination of augmented reality and a virtual world.

1. Introduction

The digital age has drastically changed the traditional definition of the museum. In the past, the entire experience in a museum has revolved around appreciating and getting educated about artifacts on display, whereas museums are now becoming more important as comprehensive social learning spaces. Such a change in the role of the museum has led to a variety of discussions about the museum space. The prevailing discussion concerns specifically the ubiquitous museum (Han, 2006). The focus of the discussion has evolved from the traditional museum to the modern museum, and from the cyber museum to the digital museum. While the traditional museum promoted preservation techniques for analog content, the modern museum contributed to the creation of images and other educational content aside from artifacts and subsequently to the development of exhibition methods. The internet age witnessed the creation of a cyber exhibition space in which digital content has evolved. The digital age, then, has unified online and on-site museum spaces while transforming the entire space of the museum using ubiquitous technology.

Along with the functional changes of museums, the content aspect of museum exhibition has also seen a change towards the expansion of experiential space. First, it means an exhibition space as physical space (Yoo, 2010); and then as electronic space, in which online information distribution takes place. Next is an exhibition space as ubiquitous space, which combines physical and electronic spaces where the spectator and the space interact with each another. Lastly, an exhibition space serves as an eXperience space. In this space, the spectator, artifacts, and devices are connected together and the user's content experience becomes an important element. Such changes have had a significant impact on the exhibition design of museums. Instead of merely involving displays, kiosks, and audio guides, creating user experience scenarios has become vital to exhibition design. It also means that emphasis is now laid upon user experience through a combination of digital technology and museum content. Now, museums need to come up with how to maximize spectators' experience beyond their experience of physical elements.

In these circumstances, the museum spectator's experiential content has rapidly evolved. When digital technology was first applied, online museum content has been transported over to mobiles thanks to widely available smart technology. It indicates not only a change in the means of delivering information, but also the expansion of the spectator's experience to aug-

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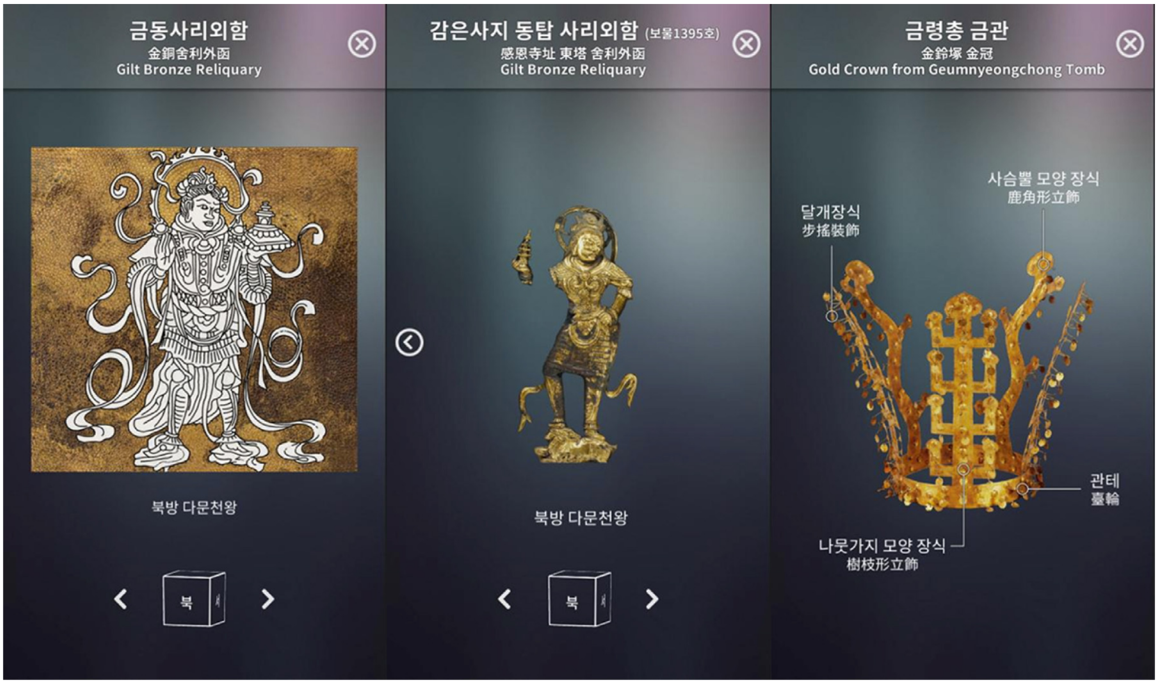

Fig. 1. The National Museum of Korea's augmented reality app screen.

Fig. 2. Korean Beomjong (Buddhist bells) experience digilog book screen.

mented reality or virtual reality. Still, however, the content of spectator experience has not moved beyond one way of delivering information. With user experience scenarios not adequately translated to storytelling, technologies have been prematurely deployed. Examples include recently deployed HMD-enabled content or beacon-enabled location-based content services. This article explores how to provide spectator experiential content by deploying digital technologies, focusing on special exhibitions in museums. First, the article examines the current state of ubiquitous technology and museum exhibition experience. Second, it discusses the current state and limitations of technologies necessary for current museums to provide experiential exhibitions. Lastly, the article suggests the concept of a service necessary to maximize spectator experience in a museum include content management system.

2. Body

2.1. Current state of ubiquitous technology and museum exhibition experience

Ubiquitous technology has rapidly evolved along with the evolution of digital technology. Such an environment based on network and mobile technologies has led to the creation of a content environment in which real and virtual spaces are integrated through various sensors mounted on devices. In such integrated space, service providers and users have produced a great variety of derivative information through two-way information delivery. It distinguishes itself from previous one-way information delivery and creates a user-centered information environment. Such technological development has been accompanied by the evolution of museum content services. These environmental changes account for the recently shifting focus of museums to ubiquitous virtual reality. However, what is now called an evolved form of exhibition content is confined to the scope of augmented reality and virtual reality. It is true that the ability of a museum to provide content that cannot be experienced in real space by combining it with virtual space, in and of itself, is progress. However, to create more evolved exhibition content requires the convergence and deployment of ubiquitous technologies (Fig. 1). Content created through ubiquitous technologies has the following three characteristics (Woo, 2011). First, it connects reality to a virtual world. By linking the real world to its corresponding virtual world, it enables two-way interaction between those two spaces. Second, it augments the tangible. Augmentation of the tangible stimulates all five senses in three-dimensional space to give a sense of reality. Third, it allows for real-time two-way interaction. It technologically connects virtual and real worlds, adding naturalness and enabling broader experience of augmented reality. Among such forms of ubiquitous content, augmented reality-based ubiquitous content is most commonly applied. The most widely deployed smartphone

Fig. 3. Jeonju Hanok Village spp screen.

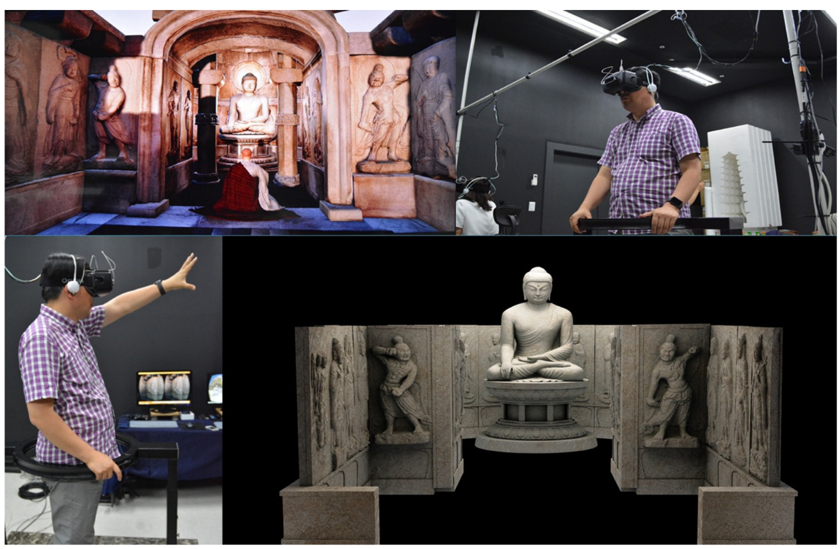

Fig. 4. HMD display screen for the Seokguram Grotto.

application for augmented reality is also widely utilized in museums.

However, this smartphone application of augmented reality is only used for one-way delivery of information on museum artifacts. In other words, it still lacks interactive storytelling. Second, there is an interactive digilog digital + analog book, which is a next-generational e-book. It allows readers to view content in 3D on 2D plane and experience audiovisual information from multiple perspectives (Fig. 2).

While this may demonstrate an evolution from previously AR-based e-books, it does not expand user experience except the fact that 3-D information and multimedia information have been enhanced.

There is also context-aware mobile augmented reality (AR). It collects contextual information from users through their individual mobile devices and utilizes the information to provide personalized information in real space. For instance, the Jeonju Hanok Village mobile app provides information on recommended restaurants and places aligned with user preferences and suggests itineraries (Fig. 3).

Context-aware mobile apps are capable of offering individual users personalized information, but obtaining contextual information through mobile devices can be a problem in that users may obtain unsophisticated contextual information. Since such apps should also take into consideration constant changes in individual contexts, it can be more unrealistic than contextual information obtained using big data. Furthermore, it can pose security and privacy risks.

Fourth, there is HMD-based augmented reality. This method allows virtual world experience and interaction through an HMD in dynamically changing real space (Fig. 4).

This method offers what is nearly close to virtual reality and a tour inside the Seokguram Grotto through the HMD, along with detailed information, for people who cannot actually visit. The use of the Oculus Rift can also allow users to experience walking in virtual reality. However, using current Oculus Rift technology still involves an injury risk and makes only virtual space meaningful

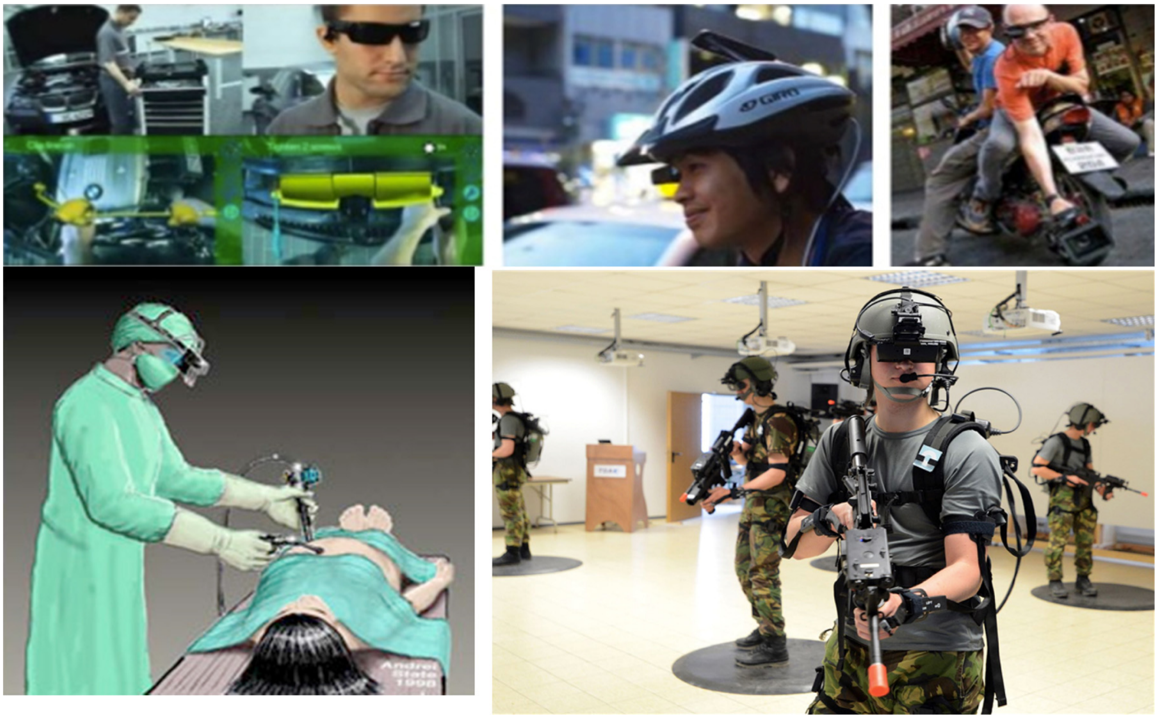

Fig. 5. Various types of HMDs.

Table 1
Progress in HMD development.

Product	Display Resolution	Display Type	Display Size	Refresh Rate	Field of View	Lens Type	Positional Tracking
FOVE	2560 × 1440; single panel 1280 × 1440 per eye	WQHD	5.8”	90 Hz	100°+	Aespheric	Lighthouse, Optical – Laser Based; 360°
GameFace	2560 × 1440; single panel, 1280 × 1440 per eye*	OLED		75 Hz	140°		Lighthouse, Optical – Laser Based; 360°
Gear VR (Note 4)	2560 × 1440; single panel, 1280 × 1440 per eye	Quad HD Super AMOLED	5.7”	60 Hz	96°		None
Gear VR (S6)	2560 × 1440; single panel, 1280 × 1440 per eye	Super AMOLED	5.1”	60 Hz	<96°		None
HTC Vive	2160 × 1200; across two screens, 1080 × 1200 per eye			90 Hz	110°	Fresnel	Lighthouse, Optical – Laser Based; 360°
Oculus Rift, CV1	2160 × 1200; across two screens, 1080 × 1200 per eye			90 Hz		Hybrid	Camera Based, 360°
Oculus Rift, DK1	1280 × 800; single panel, 640 × 800 per eye	LCD	7”	60 Hz	110°	Aspheric Acrylic	None
Oculus Rift, DK2	1920 × 1080; single panel, 960 × 1080 per eye	OLED	5.7”	75 Hz	100°	Aspheric	Near Infrared CMOS Sensor
OSVR Hacker Development Kit v1.2	1920 × 1080; single panel, 960 × 1080 per eye	OLED	5.5”	60 Hz	100° (150° with Wearality lens upgrade)	Aspheric (Regular), Fresnel (Wearality)	IR-LED Faceplate with External Camera, approx 210°
Sony Morpheus	1920 × RGB × 1080; single panel, 960 × 1080 per eye	OLED	5.7”	120 Hz	100°	–	Camera Based, 360°

while rendering real space almost meaningless, so it still is a limited form of experiential content.

The above-described ubiquitous content has significance in various aspects, but as museum exhibition content, it has several limitations. The biggest problem is that the interactivity between the viewer and content does not extend beyond simple menu operations. In a user experience scenario, a story does not get diversified but only a simplistic story is experienced. Another problem is that real and virtual spaces are not well integrated but still clearly separated. In other words, in augmented reality, real space is merely an interface for moving into virtual space. These problems can be viewed as the limitations of ubiquitous content. To resolve such

Fig. 6. Scene of the Seokguram Grotto HMD travel experience.

Fig. 7. Gangjin Goryeo Celadon Museum's HD screen.

problems, an exhibition space in a museum should exist meaningfully as real space, on which stories are told traveling back and forth between virtual and real spaces.

2.2. Current state and limitations of HMDs

To create ubiquitous exhibition content requires technology and device suitable for virtual reality. Currently the most popular device in the virtual reality field is a head-mounted display (HMD). It literally means a display worn on the user's head. Unlike TV or large-sized screens, this device featuring a small-sized screen, once worn on your head, gives the experience of looking at a large-sized screen. Along with HMDs for military and gaming purposes, today's HMDs have evolved through a variety of sensor and wireless technologies. The most well-known of them all is the Oculus Rift. Unlike existing HMDs, the Oculus Rift utilizes sensors to detect the movements of the user and show them on the display. For instance, when the user turns their head to the left, the screen also turns left. The device helps create 360° virtual reality and a diversity of virtual reality content. The recent popularity of virtual reality has prompted many companies including Sony, Samsung, LG and Google to develop advanced HMDs (Fig. 5).

The development of the HMD has had considerable effects on content as well. Previous HMDs required control devices such as a joystick to manipulate the screen, whereas current HMDs do not need such separate controls but let the screen be manipulated by users' turning of their heads. However, there are limitations as well: China's Magic Glass (暴風魔鏡) comes with a joystick and Samsung's Gear VR head mount with control buttons as auxiliary devices for screen control purposes.

Since current HMDs enable screens through smartphones, they can control screens using gyro-sensors featured in smartphones. For instance, Samsung's Gear VR allows the mounting of the Galaxy Note 4 and LG's VR for G3 is a cardboard dedicated to the G3

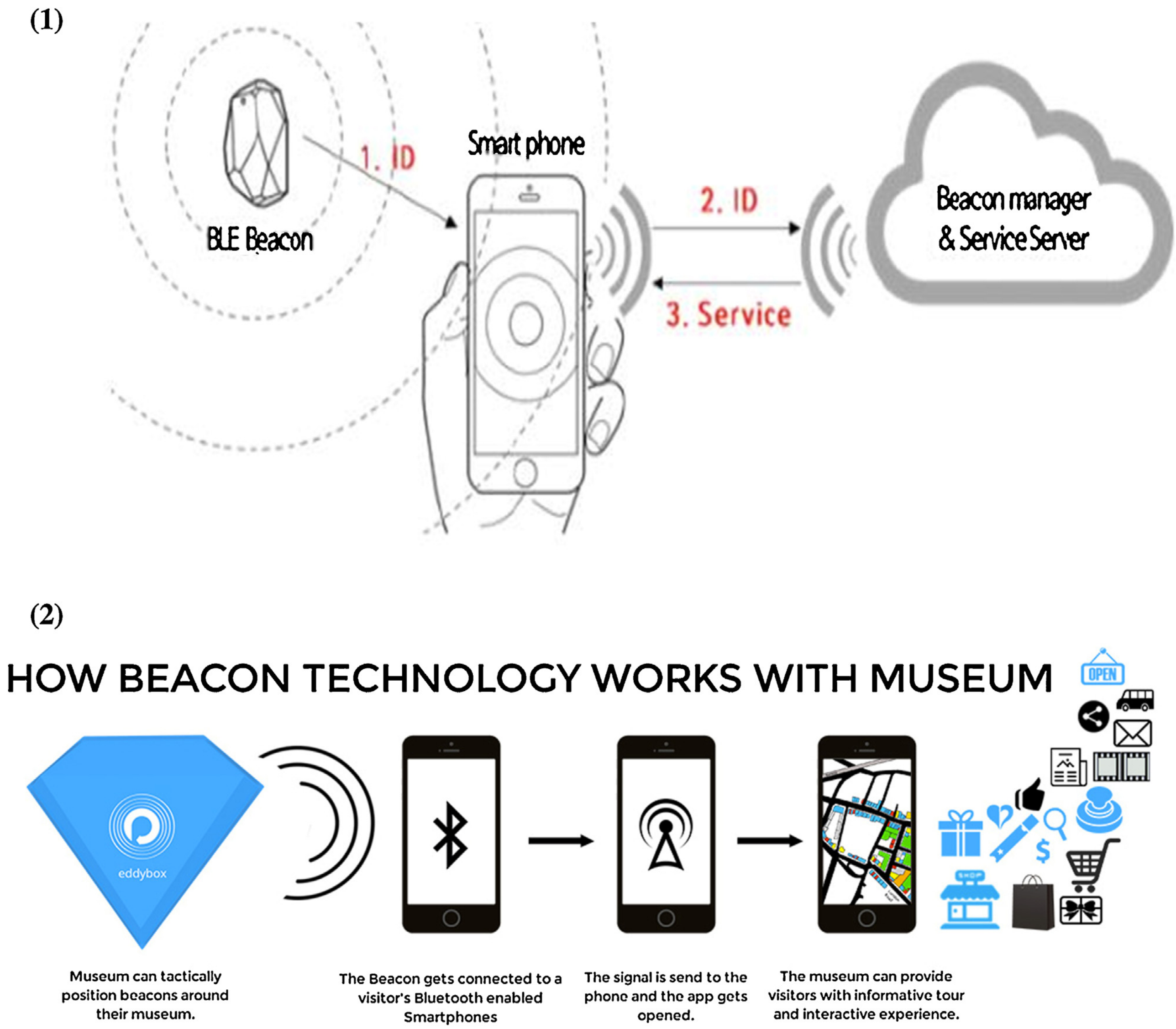

Fig. 8. (1) Schematic diagram of beacon service. (2) How beacon works in museum.

smartphone. Once combined with the smartphone, the HMD can add a whole different dimension to our experience (Mason, 2015) (Table 1).

The HMD has received enormous attention because it can produce intense immersion. Once users wear HMDs, they are able to focus on changes on the screen occurring right in front of their eyes without other interferences. HMDs enable absolutely higher levels of immersion in content than any other virtual reality device does. Since HMDs utilize smartphones, they do not require separate devices or cables for displaying images and sounds. They also use GPS, geo-magnetic sensors, and gyroscopes featured in smartphones, reducing costs and allowing users to design content so that they can experience a diversity of virtual reality experiences (IICPT, 2015).

An example of the deployment of the HMD in a museum is the Seokguram Grotto HMD Travel Experiential content. When deployed in the National Museum of Korea and the Millennium Tower in the Gyeongju Bomun Complex, the content has garnered positive reception from visitors during the Gyeongju World Culture Expo (The Seokguram Grotto HMD Travel Experience, 2015). The service offers a variety of content through the Oculus Rift, such as the inside of the grotto inaccessible to the general public, an explanation about the structure of the grotto, and the building process of the grotto. People can view every part of the grotto while walking around in it (Fig. 6).

However, in the present case, interactivity means that a spectator views content by selecting a menu. It is not interactive content in the true sense of the word. Furthermore, it only pertains to a certain real space that has experiential equipment. In other words, a real space is not constructed as the Seokguram Grotto, but it just functions as a location for installing the Oculus Rift. Technically speaking, it is virtual reality content rather than augmented reality content. It is thus necessary to incorporate the characteristics of real space, which is an exhibition space.

In addition, the most serious limitation of the current HMD is that spectators feel uncomfortable walking around while wearing the HMD. The difficulty stems from the fact that the display shows a virtual world, instead of the real world. So far, the HMD has only enabled efficiently experiencing of a virtual world in a fixed space. As with the theme mark case, visitors can experience a virtual world while wearing the HMD and walking around as if they are riding a roller coaster. However, people are still stuck on the roller coaster and it is only one way delivery of content. It merely provides a virtual space, instead of the experiencing of traversing back and

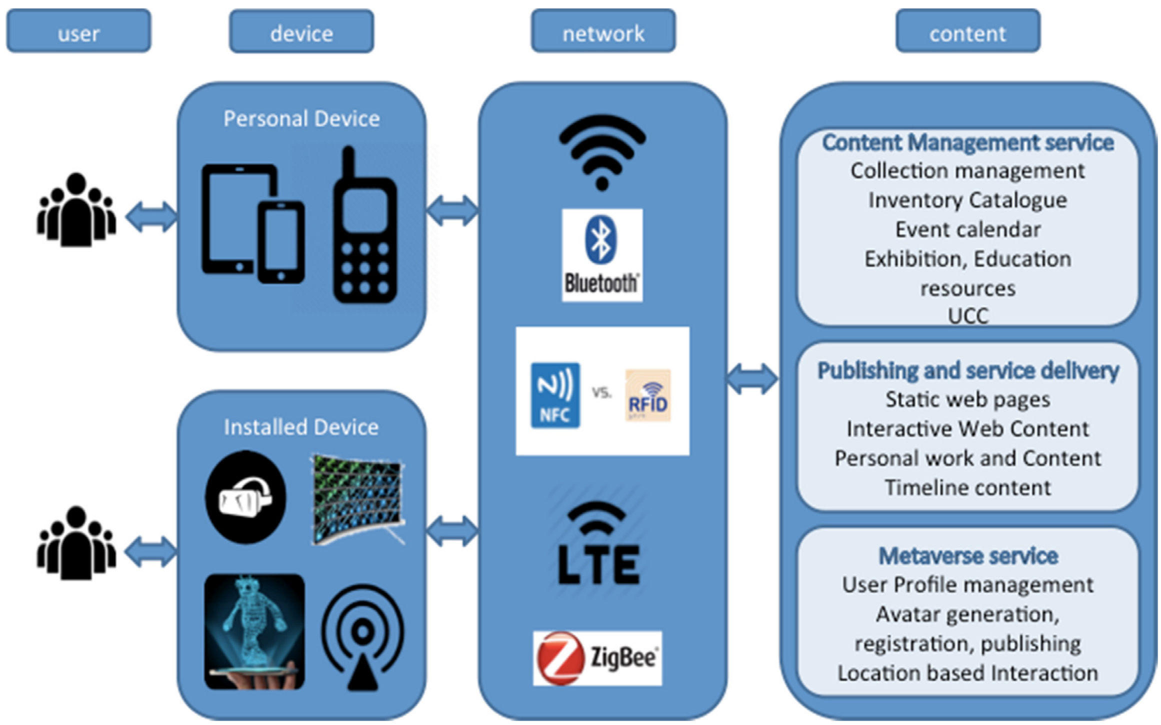

Fig. 9. Schematic diagram of the museum exhibition experiential content service.

forth of real and virtual spaces. Therefore, it is important to realize augmented reality using the HMD. It can be made possible based on the fact that most of current HMDs utilize smartphones as display units. Using the camera feature on a smartphone helps realize augmented reality experiential content.

2.3. Plan to deploy augmented reality in exhibition rooms at museums

Museums are real spaces, and each space holds artifacts that distinguish the museum (Falk & Lynn, 2012). Fundamentally, exhibition content in the museum should be based on the real space of an exhibition room. If exhibition content is only offered as virtual reality, visitors have no reason to visit the museum. It is thus necessary to think of exhibition content for museums as augmented reality rather than virtual reality. Currently, augmented reality content in a museum context only serves to provide information. Many museums develop their own applications and provide them to visitors, but after showing a little interest, most first-time users do not become active users. This is because there is little change in content until new content has been created. It is also because spectators and content do not interact with each other, but spectators receive museum guides unilaterally through apps. Exhibition content for museums should thus contribute to the diversification of user experience through various storytelling strategies (Ando, Thawonmas, & Rinaldo, 2012).

To that end, real space in exhibition rooms must be analyzed first. Through analysis of artifacts that are displayed in an exhibition room; the characteristics of those artifacts; stories related to those artifacts; experiences that spectators will have by seeing those artifacts, user experience scenarios must be created. For example, when a visitor enters an exhibition room dedicated to Goryeo celadon, the exhibition should provide the visitor with such information as the chronological evolution of Goryeo celadon, various patterns, what those patterns symbolize, and differences between Goryeo celadon and other pottery. Then based on the information, experiential content can be created (Hirose, 2005).

The most distinct characteristic of Goryeo celadon is its pale green color, and several pigments were mixed to produce this specific color. The museum will then provide spectators with experiential content showing the types of pigments and their mixing ratio to create the pale green color. In another scenario, a spectator can also become a potter who makes Goryeo celadon in virtual reality by wearing the HMD and participate in the creation process. If the spectator-potter chooses the wrong pigments or mixing ratio, the resulting celadon will have the wrong color. Just as Goryeo potters did, the spectator may well shatter the celadon with the wrong color in virtual reality. The spectator's movements will enable various experiences. Storytelling is a process by which spectators create their own stories. The conveying of past events only forms a story rather than storytelling. User experiences can include making colors and firing potter in an oven. In virtual reality, spectators can adjust oven temperatures and check if pottery has been properly fired (Fig. 7).

However, an exhibition room holds more than just one artifact. There are several artifacts, and those artifacts may be correlated with one another or have different characteristics. For instance, a single display space may exhibit paintings by the same painter, or paintings by different painters of the same period. It means that each display space has a specific theme. In other words, an exhibition space is characteristically like a gathering place of specific themes. It may be easy to create a single theme into experiential content, but it is not easy to make several themes into several themes. Furthermore, exhibition spaces are indoor spaces that are hardly extremely vast, making it difficult to provide location-based information services (Ogiela & Ogiela, 2014a). While information services are available in the form of IR, RFID, or QR code, it is still one-way information delivery. For museums to provide experiential content by theme in an exhibition space, different technologies should be deployed (Thawonmas & Kato, 2012).

An increasingly popular technology in this context is the beacon. The Bluetooth-based beacon service is very useful since it is enabled by a very accurate location-based technology (NIA, 2014) (Fig. 8).

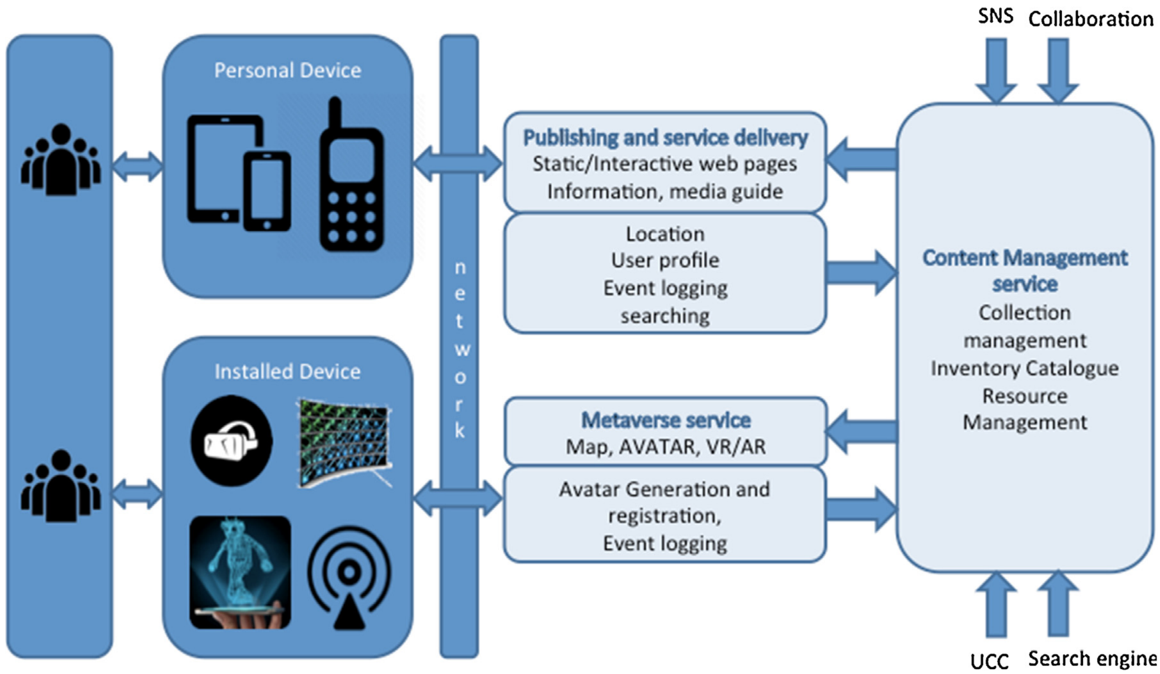

Fig. 10. Structural diagram of the museum exhibition content service.

Since the aforementioned HMD utilizes a smartphone as a display and features various sensors, it is also suitable for use with beacons. If beacon dongles are installed by theme in exhibition rooms, when spectators wearing HMDs approach a certain beacon dongle, they will receive information about the beacon through their smartphone app featured in the HMD and enter a virtual world. Spectators can return to the camera screen from the HMD screen before receiving information from the beacon or after having finished VR experience, and continue to look around artifacts in the exhibition space. In other words, while looking at artifacts in real space, visitors can enter into VR experience when approaching a certain beacon and receiving a link to content related to a certain theme, which sends VR content to the HMD screen, and, after finishing VR experience, return to artifacts in real space. Through the combination of HMDs and beacons, museum visitors can simultaneously view artifacts in real space, an exhibition room, and experience VR content in virtual space (Verdot & Saidi, 2011).

Then, as with the Seokguram Grotto case, an experiential space does not merely serve as an installation location for devices, but is also assigned site-specificity that allows visitors to view and experience actual artifacts in an actual exhibition space. Real and virtual spaces will then be able to become naturally integrated. One problem remains unsolved, however—which is the risk of suffering injuries while wearing the HMD and doing the viewing and experience in an exhibition space at the same time. Since visitors experiencing a virtual world cannot see the actual exhibition space, they may bump into other visitors when they move. This problem can be solved by creating an experience zone in the location where a beacon dongle is installed and having visitors enter the zone to operate virtual reality. Once spectators step outside the experience zone, virtual reality will then cease to function and the camera lets the spectator view the exhibition room.

3. Conclusion

The schematic diagram of the museum exhibition experiential content service discussed above can be illustrated as follows:

While the museum exhibition experiential content service can be deployed in all exhibition rooms, realistically it is not easy to visit every part of the museum with the HMD on. The present service should be then applied to rooms holding special exhibitions. In other words, museums can select certain themes for special exhibitions and provide experiential content for visitors based on storytelling scenarios aligned with the theme (Fig. 9).

More importantly, this type of service can be called "metaverse exhibition experiential content service" since it can expand spectators'experience by allowing them to journey back and forth between real and virtual spaces. The metaverse is a compound of the words "meta" (which is an abstract concept) and "universe" and means a space created by the convergence of virtual and augmented reality (Kim, 2014). The fundamental axes (lines) of the metaverse include one of augmented reality and simulation, and one of internal and external elements; on the four planes are the four key elements—augmented reality, virtual world, lifelogging, and mirror world (Smart et al., 2007).

Augmented reality can be realized by focusing on a certain artifact and providing information about that artifact. A virtual world in this case means a spectator's experience of a story related to the artifact directly or through the agency of an avatar. Lifelogging refers to logs related to everyday events executed by spectators through the use of the service. A log analysis will help derive the behavioral characteristics of the spectator and, through big data analysis, plan the delivery of personalized content to the spectator. A mirror world means a reproduction of the real world. The aforementioned museum exhibition experiential content service can incorporate all of the four elements of the metaverse; in other words, the content can be called metaverse exhibition content.

Content Management system is crucial for all of the exhibition system, because it controls collection of logs profile and search history, inventory management and resource management for metaverse service and publishing delivery system. It also manages inbound resources such as SNS feeds, various UCCs and collaborated search engine log and history for service delivery. It provides basement of various services by content and information management.

Information used in the metaverse or logs built through the metaverse can be provided as new content. It can be provided through a mobile or web, or it can help construct a cyber museum exhibition space that provides spectators with personalized information. As with Google's Art Project, spectators can visit exhibition spaces in a museum, view experiential content and receive basic information in cyber-mode (Google Art Project, 2016). Content can be used in a wide range of applications. This technology can also expand the museum exhibition experiential content service (Ogiela, 2015). The service can be linked with existing museum digital archives and content management systems (Ogiela & Ogiela, 2014b). It can function as a ubiquitous museum service. The following suggests the structural diagram of the service:

The article has discussed how to deploy experiential content in museum exhibition spaces by combining the HMD and beacons. The development of advanced technologies has broadened our scope of experience. However, broadening experience must be aligned with the purpose of the content that our experience offers. Content provided through simple menu operations or simple displays cannot be considered to be properly deployed experiential content. Metaverse exhibition content can only be created when spectators are allowed to create their own stories and offer diversifying experiential content (Fig. 10).

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