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Design and Implementation a Virtualization Platform for Providing Smart Tourism Services

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***Abstract*—**This paper proposes an Internet of Things (IoT) based virtualization platform for providing smart tourism services. The virtualization platform provides a consistent access interface to various types of data by naming IoT devices and legacy information systems as pathnames in a virtual file system. In the other words, the IoT virtualization platform functions as a middleware which uses the metadata for underlying collected data. The proposed platform makes it easy to provide customized tourism information by using tourist locations collected by IoT devices and additionally enables to create new interactive smart tourism services focused on the tourist locations. The proposed platform is very efficient so that the provided tourism services are isolated from changes in raw data and the services can be modified or expanded without changing the underlying data structure.

***Keywords*—**Internet of Things, IoT platform, service platform, virtual file system.

I. Introduction

WITH the widespread of use of smartphones and high-speed Internet access, users can obtain information almost anytime and anywhere. As of March 2016, the smartphone penetration rate in South Korea reached 91% [1]. It is expected that 5 billion people, 66% of the world population, will use smartphones in 2018 and that the mobile Internet market will generate up to $11 trillion in economic value by 2025 [2]. Increasing number of users will access information using mobile devices. These progresses have resulted in big changes in our lives. A number of smartphone applications have been developed and users are expecting more and more smart services. Many smartphone applications are now equipped with new technologies such as virtual reality, augmented reality, and artificial intelligence [2]. Following this trend, the tourism business sector also has been evolving and provided smarter services. Researches on tourism services based on visitor locations have been actively conducted [3]. Highly customizable services according to interests and plans of a particular tourist have also been studied [4]. The methods of selling and purchasing tour products as well as the tastes of tourists have been diversified. Tourists also have become smarter and more active. They obtain information, share their own experiences and know-how, and evaluate tourism companies in numerous online communities.

Tourism is the world's largest industry and studies predict its increasing growth. Tourism contributes greatly to the economy of a province or a country. Tourism depends heavily upon the attractiveness of the destination's resources such as natural, cultural, and social resources. Information for tourists is one major component of the social resources. To promote tourism, it is of significant importance to provide useful information for prospective tourists. Almost every country or city provides tourism information via Internet as well as off-line information centers. The pervasive use of mobile devices has resulted in changes in the way of tourism promotion. Many governments provide mobile apps developed to deliver tourism information in a smarter way.

It is not easy to manage vast amount of tourism information, update related information simultaneously, and provide the collected information in an effective way, which is essential for smart tourism services. This paper proposes a service platform based on IoT virtualization for the purpose of providing smart tourism services.

II. Related Works

Smart tourism is defined as providing customized services for tourists based on real-time communication and location information. Fig. 1 shows fivr major components of smart tourism [5].

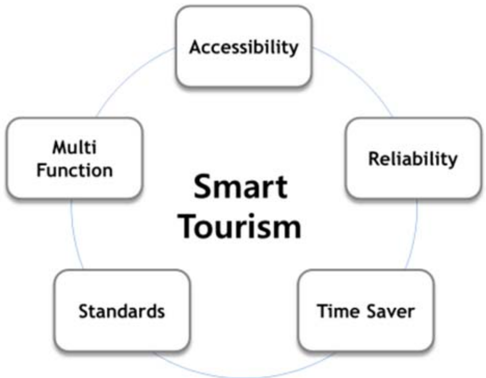

Fig. 1 Components of smart tourism

An example of smart tourism service is the so-called *Every Corner of Korea*, a smartphone app serviced by Korean Tourism Organization. The app provides tourism information on every nook and cranny of the country and recommends best travel themes according to seasonality. It also provides special accommodation information such as camping grounds and temple stay programs and additional information such as representative sightseeing spots, and ecotourism [6]. Korean Tourism Organization also opened an application programming interface (API) named *TourApps*, which facilitates convenient

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use of more than 30,000 pieces of domestic tourism information including accommodations, restaurants, and nationwide festivals. It is expected that the API contributes to the vitalization of the domestic tourism industry and the development of smartphone apps for tourism. Smart tourism services are also found overseas. The Louvre-DNP Museum Lab of the Louvre Museum in France is another example. Using advanced technologies such as augmented reality and 3D video technology, it provides the art works vividly for audience [7].

It requires a great amount of money and time to operate bidirectional smart tourism services using real-time on-site data. It is essential to develop a service platform that facilitates smart tourism services based on bidirectional communications. Most of the currently used platforms focus on services rather than collecting and managing data. It is therefore necessary to devise a platform that can support integration, management, and analysis of various types of tourism information and data collected by a great number of IoT devices.

The detection of tourist locations is the core component of smart tourism services. The detection is performed using short-range wireless communications in most cases. Related short-range communication technologies include BLE, ZigBee, and NFC. Table I shows the properties of three wireless communication protocols. If WiFi connection is available, NFC may be a good option. If not available, BLE beacons can be used.

TABLE I
SHORT-RANGE WIRELESS COMMUNICATION PROTOCOLS

Property	BLE 2016	Zigbee 2016	NFC 2016
Frequency (MHz)	2,402 ~ 2482	868-868.8, 902-928, 2402-2482	13.56
Channels	3	16	1
Modulation	GFSK	BPSK & QPSK	ASK
Max data rate	1 Mbps	250 kbps	424 kbps
Range	10 m	100+ m	10 cm
Power profile	Days	Months/Years	Months/Years
Complexity	High	Low	Low
Nodes/Master	7	65,000	1+1
Extendibility	No	Yes	No

III. IOT VIRTUALIZATION PLATFORM

The system proposed in this paper is designed to store the GPS information of the tour spots and to provide information for the areas around the current location. We are expected to collect tourist locations by using beacons to provide information based on the locations.

The IoT virtualization platform can collect information from not only legacy devices but also any IoT devices equipped with TCP/IP communication interface. The platform is composed of several major elements such as a virtual file system (VFS) for managing data as files, a storage element (SE) for storing data, an information system (IS) for storing system information, and a management daemon. It additionally provides a computing element (CE) for data analysis, a job schedule server (JSS), an IoT-storage element (IoT-SE) for collecting data, an IoT-device manager (IoT-DM), a command line interface (CLI), and a web user interface (UI) [8]. The detailed configuration is shown in Fig. 2.

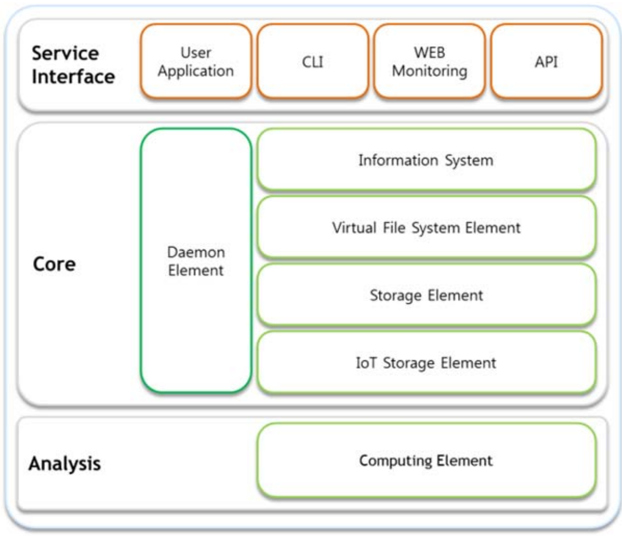

Fig. 2 Components of IoT platform

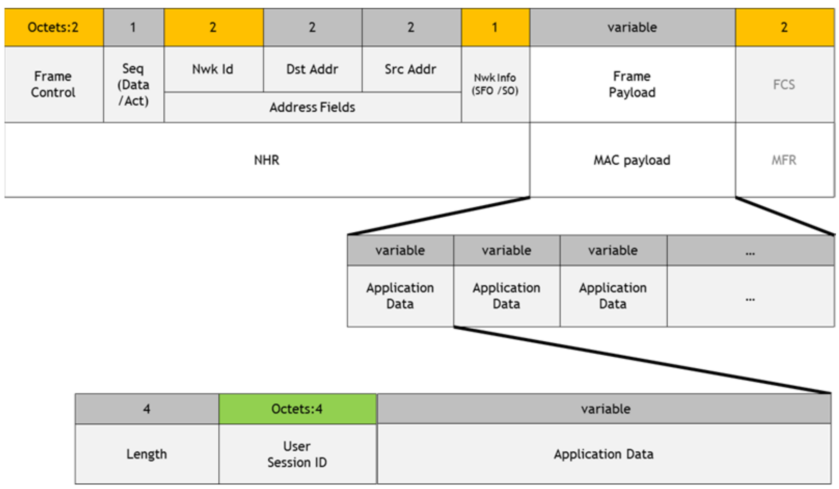

Fig. 3 Packet format for the components of IoT platform

The components of the platform use socket communications with a predefined packet format. The packet is defined based on IEEE 802.15.4 and is designed to be capable of uploading data collected in WPAN environments to the platform. The detailed packet structure is shown in Fig. 3.

The virtual file system is implemented based upon the Linux file system and can execute Linux-like commands through the command line interface (CLI). The platform stores actual data and the metadata for the actual data separately. All data collected by the platform are stored in the storage element and the metadata for the collected data are stored in the virtual file system element. Storing metadata and actual data separately eliminates the spatial constraints of data storage. In addition, it is possible to process only metadata for tasks that do not use the actual data, thereby reducing unnecessary I/O. The biggest advantage of the virtual file system is that data can be loaded into predefined categories. Fig. 4 shows an exemplary data categorized in the virtual file system. In the case of existing RDBMS, the data should be saved according to an existing DB structure. If a table is changed or added, the program that handles loading data also needs modification. The IoT virtualization platform allows developers to determine the data structure flexibly in such a way that the required services can be provided more easily.

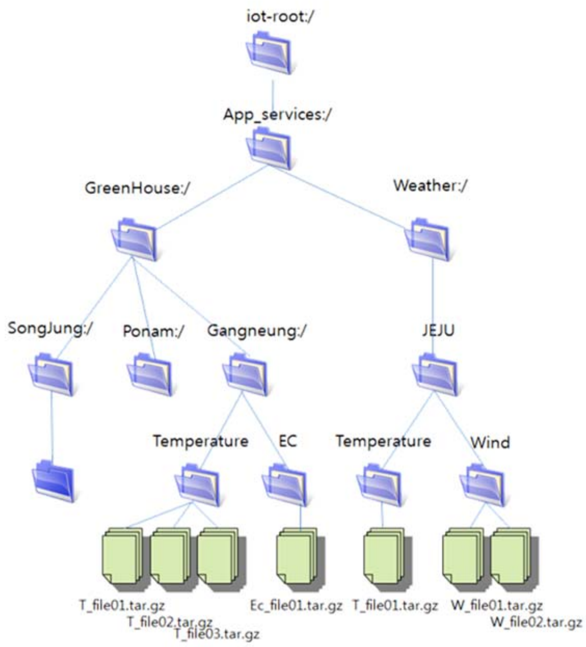

Fig. 4 Virtual file system

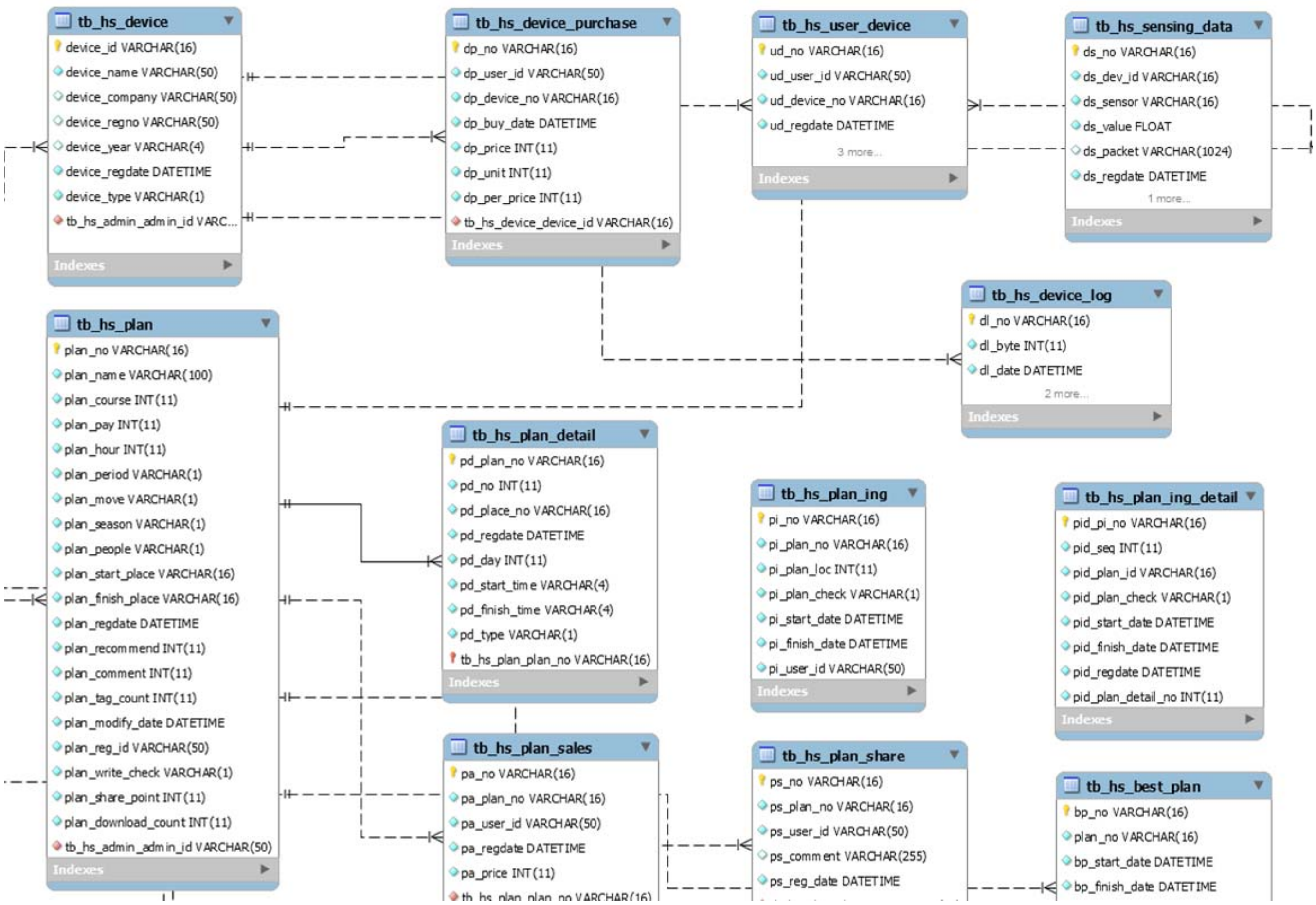

Fig. 5 A part of the entity relationship diagram for implementing services

Since the data in the IoT virtualization platform are managed as files and/or directories, we organize tourism information of target areas in two ways. One is classified by regions and industries, the other one is classified by industries and regions, and both are linked with service DB through API. Data managers can easily modify tourism information stored on the proposed platform simply by downloading data from the platform, modifying, and uploading again. In the case where some files are modified, the service DB can be updated by executing commands, which also updates in real time service pages related to the modified files. As a result, this method helps to save time for updating service pages and leads to greater flexibility in managing data.

IV. Implementation of Smart Tourism Services

The most crucial factor that should be considered in the design of database for smart tourism services is how to provide tourism information efficiently. We use a database having 45 entities as shown in Fig. 5.

The major services provided based on the designed database include general tourism information, itinerary planning, itinerary recommendation, device management, and data management. The database makes it possible to provide tourists with interactive services for planning, sharing, and modifying itineraries. The service manager can control IoT devices and manage data collected by IoT devices by utilizing the functions of the IoT virtualization platform.

The used programming language is Java, the development tool is Eclipse (Spring Tool Suite, ver 3.8.0), the database is MySQL, and the webserver is Apache Tomcat server. Table II briefs the development environments. Fig. 6 shows the screenshots of the web page. It adopts responsive web design so that the page can be shown conveniently also on mobile devices with small screen sizes.

The whole system consists of one tourist information service server and four servers for the IoT virtualization platform. Fig. 7 shows the configuration.

TABLE II
Development Environments

Property	Name
OS	Windows 7 64bit
DB	MySQL 5.7.16
DEV	JDK 1.8.0_111
WAS	Apache-tomcat-8.0.39
Tools	Eclipse (Spring Tool Suite, ver 3.8.0)

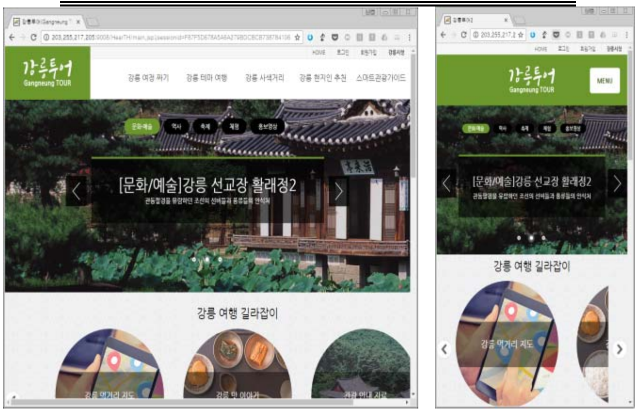

Fig. 6 The web page screenshots

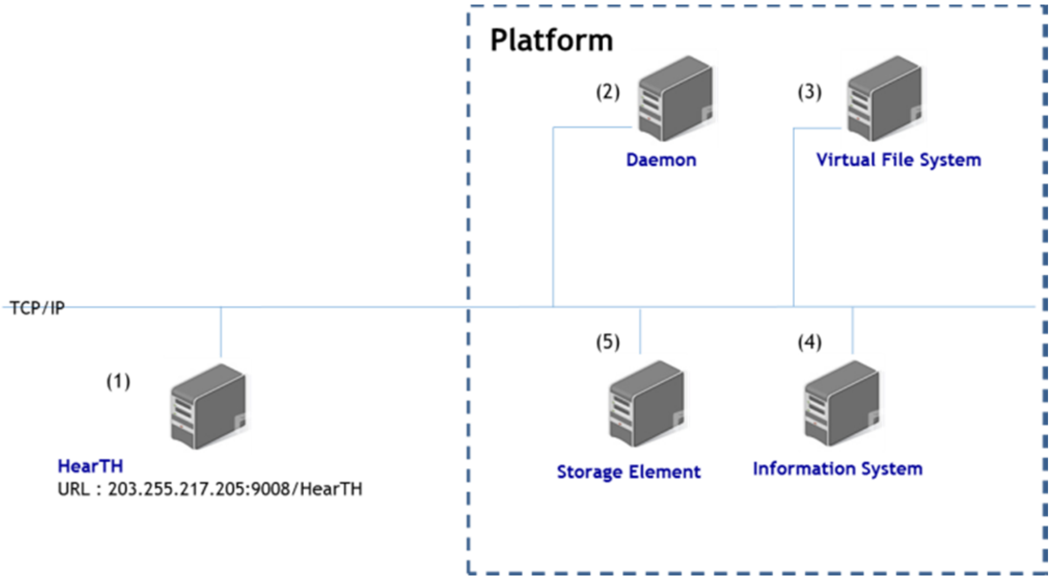

Fig. 7 The configuration of the whole system

The administrator uploads tourism information to the IoT virtualization platform as files and applies the information to the service. Fig. 8 shows the process by which services are updated on the virtualization platform. If the administrator uploads information files using the client program, daemon element loads the files onto the platform. If the administrator issues a command for updating the service database, the daemon sends the files to the data manager. Receiving the files, the data manager updates the service database. The administrator can check the update result in real time through the web server. In addition, the administrator can access the platform and download previously uploaded files, modify the downloaded files, and upload them for updating the web page. Since the administrator can modify the information loaded onto the platform easily, the contents of the web page are easily kept up to date.

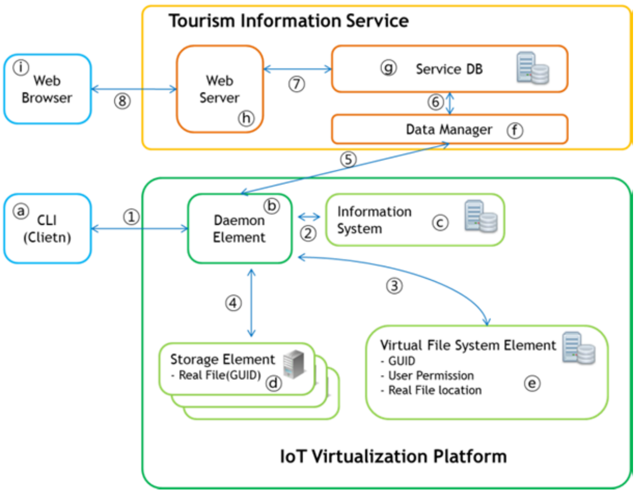

Fig. 8 Data update process

The use of the proposed virtualization platform has several advantages over the conventional systems. First, using the IoT virtualization platform makes the management of information much easier. In the conventional systems, if some data tables are modified, the program responsible for providing services based on the tables should be modified accordingly. Also, it is not easy to modify the existing data structures or tables in such a way that tourism services can be provided more easily. In the virtualization platform, on the other hand, the service database can be updated directly from the files existing on the platform, and the data stored on the platform can be downloaded, modified, and uploaded again to the platform, and immediately reflected on the provided services. Second, it facilitates the handling of heterogeneous data. Different types of data can be stored in the same directory. For example, tourism information regarding an area and data collected in the area by IoT devices can be put in the same directory and managed in the same manner. In addition, it makes it easier to analyze the correlation between heterogeneous data stored in the same directory through searches and modularization.

V. Conclusion

This paper proposed an IoT virtualization platform for providing smart tourism services and introduced an example of tourism services implemented on the virtualization platform. A major problem with most tourism services is that the constant update of tourism information and modification of existing data structures costs a considerable amount of money. The proposed IoT virtualization platform makes it easy to provide interactive services by separating actual data and metadata for the actual data and making data structures more flexible. Also, the proposed platform allows heterogeneous data from different sources to be handled in the same way, which makes the update of service information much easier.

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