IEIE Transactions on Smart Processing and Computing, vol. 3, no. 2, April 2014
http://dx.doi.org/10.5573/IEIESPC.2014.3.2.74

Design of Tourism Application Based on RFID Technology

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Received November 20, 2013; Revised December 27, 2013; Accepted February 12, 2014; Published April 30, 2014

** Regular Paper*

***Abstract*:** Automatic identification is pervasive in many areas and its applicable areas are increasing gradually. 2D bar-code, NFC, and RFID technologies are representative examples of theautomatic identification. This paper explains the implementation of mobile tourism applicationsoftware on RFID technology. The mobile application provides the location and navigationinformation by combining the tag inventory and web database. The interactions among the user, application and database server are described in detail. This paper proposes a simple way of minimizing the efforts to build the entire system by storing the URLs for the tag and accessing existing tourism information services through the URLs.

***Keywords*:** RFID, Tourism, Automatic Identification, Mobile, NFC

1. Introduction

Automatic identification technologies, such as barcodes, RFID, etc. have become prevalent in inventory andtracking systems. The use of those technologies hasmany advantages and attractions as follows. 1)The technologies link the physical world and virtualworld easily by attaching identification codes on the surfaces of any object. 2) The process of object identification becomes simpler, more consistent, and more intuitive to use. 3) Those technologies are easy to integrate with pre-existing network infrastructures, particularly with the Internet. 4) Each technology has evolved to store and retrieve not only a simple identification code, but also useful data and information. 5) Data aggregation and manipulation can be automated easily. Consequently, the technologies are expected to extend their applications in many fields [1, 2].

A two-dimensional barcode [3] was developed based on the one-dimensional barcode to overcome its small data storage capacity. QR Code [4], which is one of the two-dimensional barcodes well known to the public, has data storage capacity up to thousands of characters. TheQR code was initially intended to track automotive parts, but the scope of its applicability has been extended to other fields, such as transportation tickets, sushi dishes for freshness control, tags for jewelry certification, etc.. Some people print the QR Code on their business cards linked to their homepages or social network service pages.

Another major automatic identification technology is radio frequency identification (RFID) [5]. RFID technology has the potential to improve management efficiency in terms of cost, time and accuracy of information interchange over other technologies. An anti-theft system [6] based on RFID technology has already been incorporated in many stores with an inventory management system [7]. Besides, there is NFC technology that is derived from RFID technology, working in a considerably short range. The NFC has been popularly used in payments [8, 9], automatic pairing devices for wireless connectivity, such as Bluetooth and Wi-Fi [10, 11], etc. These technologies have different characteristics and are adapted to use in a wide variety of applications ranging from industry to personal purposes.

Many studies have applied automatic identification technologies to the tourism area [12-14] because it is beneficial for tourism applications in many aspects. Examples include ”NFC Internal” [15] for indoor navigation and Smart Poster [13] for outdoor location and navigation in urban areas or commercial districts. On the other hand, despite these studies and implementations, there isa lack of satisfactory tourism applications using those technologies.

When a tourism application is constructed, it is important to consider the following issues. First, the users

are typically unspecified individuals. They require different and various types of information depending on their personal experience and interest. The implementation of a system that satisfies all the users' needs is difficult to achieve and requires enormous effort. Fortunately, a range of tour-related services are already available in the form of web services or mobile applications. Rather than build from the ground up, such as the case study reported by Borrego-Jaraba et al. [13], integrating with preexisting tour services appears to better fit when a tourism application is constructed. The second issue is the cost of deploying and managing the entire system. If a system covers a vast area and many points of interest, the cost of deployment and management increases considerably. Because each automatic identification technology has its pros and cons over others, it is important to carefully choose the appropriate technology to reduce the cost.

This paper reports a method for resolving the above issues when applying RFID technology to the tourism area. Although there are many touristic services available, tourists may feel it uncomfortable and difficult to obtainuseful information due to the unfamiliar surroundings. Therefore, a bridge was constructed between tourists and existing tourism services, which would make the process that users undergo to obtain information easier using automatic identification, particularly using RFID technology. Instead of accessing the information from each website individually, a tourist can use RFID technology to identify the location and access all the related information from several websites at one time from an RFID tag. To verify this concept, a mobile application prototype was implemented in this study. The application works on an Android-based smartphone and requires an RFID reader dongle. Note that this dongle can read the passive 860~960 MHz ultra-high frequency band RFID.

The front-end mobile application scans near the RFID tags, accesses a backend web server, receives the result of database searching, and shows the usable information requested.In the application, tourists can see the tag history, i.e., their movement history. Many technologies are available as auto identification, i.e. the frontend, but a backend system might be more important because of the device independency. In the current approach, the backend system requires no extra program and consists of only two parts; a web database and server-side script receiver files. The web database stores and manages the data that is provided to a tourist. The receiver script files catch a request from the application, check the tag ID attached to the request, and then returns the result of the database searching query using a server processor. Because the backend system is made up with the DBMS system and server-side receiver, it would be simple and easy to manage the data. Currently, the database stores the URLs corresponding to a tag ID and the titles of the URLs, respectively.

This paper reports two major contributions. First, in the process of implementation, minimal effort was made to build a mobile tourism application. The user's location identification was simplified by introducing RFID technology. Second, the existing tourism-related information services were integrated into a single application to reduce the redundant searching process, which improved user experience. As a result, the barrier to entry for developers and users was lowered by suggesting a simple way to utilize RFID technology and obtain useful information, respectively.

This paper is structured as follows. Section 2 explainsthe pros and cons of automatic identification technologies and compares them in terms of the tag-reader and frontend-backend relationship. Section 3 reports the architecture of the proposal and its implementation. Finally, Section 4 presents the conclusions.

2. Background of the Automatic Object Identification System

2.1 Comparisons of Identification Technologies

Many identification technologies exist in wireless, such as Radio Frequency IDentification (RFID), Near Field Communication (NFC), and 2D barcode, such as Quick Response Code (QR code). Note that in this paper, RFID means the passive 860~960 MHz ultra-high frequency (UHF) band RFID technology and the NFC means 13.56 MHz high frequency technology. Using QR codes, RFID tags, and NFC tags can be helpful for many applications, such as logistics, augmented data, supply chain, etc. [1, 4, 16]. Table 1 lists the pros and cons of each technology.

Among these three useful technologies, RFID technology wasselected. The reasons are as follows. The 2D barcode was excluded initially. 2D barcode is based on a visual sensor and image processing. The innate line-of-sight characteristics would require more effort to use it. In addition, printed bar-code is read-only. This makes harder to replace for new data than other technologies. Thus, the management cost may increase for long term use. It is vulnerable for sabotage such as scribbling as well. Finally, a 2D bar-code requires more space to embed large data and cannot be superimposed.

Although NFC is already pervasive and supported in many smartphone devices, NFC wasnotthe best choice. First, its reading range, only a couple of centimeters, could be difficult to use in tourism scenarios. In contrast, RFID offers better user experience than NFC because of the longer reading range and multi-tag recognition. RFID doesnot require the users to move their device close to the tag. Second, the users can turn off the NFC at the configuration of their devices after using the NFC. Otherwise, the device will search constantly, even if there is no any other NFC device nearby, which leads to power wastage. The users should then manually turn on the NFC again when they want to use it. To some people, adjusting the configuration of their device might be troublesome. These process were changed to a plug and unplug mechanism using a RFID reader dongle. The users just need to plug in an RFID reader dongle, scan tags, and unplug the dongle when they wish to discontinue their use. The application is automatically executed and there is no more power consumption after unplugging.

Table 1. Comparison of automatic object identification technologies.

QR code	
Pros	Near zero cost for the deployment of QR codes and easy to make QR codes. Large data capacity up to 2,953 bytes for binary and 4,296 characters for alphanumeric.
Cons	Line-of-sight problem can occur because of vision processing. This can be lead to falsification. Read-only after being produced once, and therefore difficult to replace for new data or information. Affected by glare, shadows and defacement.
NFC	
Pros	Many smartphones and smart pads have already been equipped with NFC function. Mobile payment - more secure than others. Situation-based profiles - context-aware application may be provided. Plenty of re-writable non-volatile storage. Typically up to a couple of KB. Device-to-device communication is possible with a peer-to-peer mode.
Cons	Short reading/writing range, typically less than 10 cm. Practically less than 1 cm. Because of the polling loop, which is time-multiplexed switching between many modes (reader mode and card emulation mode for many different protocols), it may consume more power for usability. Relatively high cost for tag deployment. A device may perform unintended action [17].
RFID	
Pros	Longer read/write operation range than NFC, and non-line-of-sight. Multi-tag recognition. RFID tags are less expensive than NFC tags. Not a lot but still affordable re-writable memory;typically up to couple of Kbits. Higher data transmission rate.
Cons	Few mobile readersare available. Hard to use with metal or water because of reflection or blocking. Interference problem may be occurred because of reader collision.

2.2 Mobility of Readers and Tags

RFID/NFC systems can be classified into three types in terms of the mobility of readers and tags. This paper focuses on the 2nd system.

- 1) **Fixed readers and mobile tags**: Readers exist at a pre-defined fixed position. They recognize the nearby tags, gather and manipulate the necessary data, and then provide useful information using the data. This type of system can be used in access management systems, toll collection systems, etc.
- 2) **Fixed tags and mobile readers**: Tags are located at pre-defined fixed positions, such as walls, surfaces, and billboards. Nomadic users with a mobile reader device can read the data of the tags and then use them for special purposes. An information provider system at any point of interest, such as Smart Poster, etc. could be an example.
- 3) **Mobile tags and mobile readers**: RFID/NFC tags are attached to the objects. These objects may be mobile. Users with a mobile reader can read the tags' data and/or write/modify the data. An augmented memory system [18] and the Internet of Things are two examples.

2.3 Differences in implementation types

In practice, an application system consists of a frontend system and a back-end system. The front-end system is composed of RFID/NFC tags and a RFID/NFC reader equipped on smart devices. The back-end system comprises a network infrastructure and data servers that are connected to the Internet. Theimplementation can be divided into three types as follows.

2.3.1 Front-end centric implementation

RFID/NFC tags keep the most valuable information in their non-volatile memory. A reader extracts the information from the tags and then uses the information. This is called the least use of back-end system.

- Pros: An application can be independent of the infrastructure, and there is less requirement for an Internet connection.
- Cons: It is difficult to update. The size of the front-end might be too big to cover a large area because the system needs to contain almost all the data. The deployment and management cost may increase significantly.
- Possible applications: For underground, mountainous regions, wetlands, rural areas where an Internet connection is poor.

2.3.2 Back-end centric implementation

Each RFID/NFC tag has only a unique identification code.A reader reads the code and uses it to query useful information via back-end systems. The most valuable

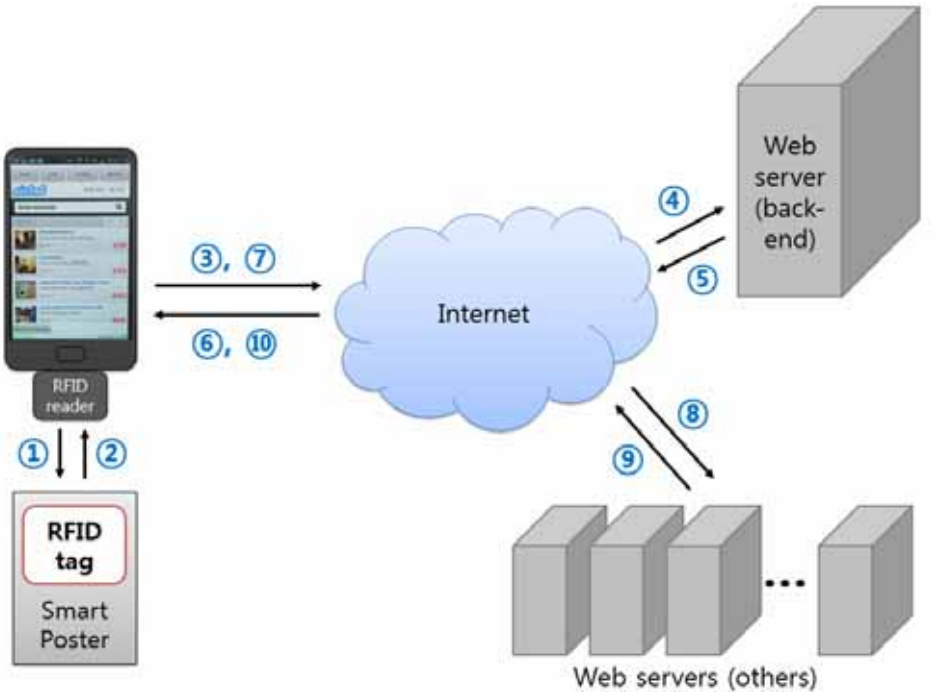


Fig. 1. Organization of the proposed system.

information and data are stored in back-end storages, such as databases. The back-end system manages and manipulates the information and data.

- Pros: Size of the front-end can be light in contrast to front-end centric implementation.
- Cons: It is difficult to update. The size of the front-end might be too big to cover a large area because the system needs to contain almost all the data. The deployment and management cost may increasesignificantly.
- Possible applications: For urban, tourist spots where the cellular network or Wi-Fi connection is activated.

2.3.3 Hybrid implementation

RFID/NFC tags keep a unique identification code and minimal basic information. A reader reads the code and information, and then provides the basic information to a user without a back-end system. The user may request the relevant information with the code to the backend system if necessary.

- Pros: Application can offer primary data without an Internet connection. With the Internet, it can obtain more detailed information.
- Cons: Balancing between the front-end and back-end can be difficult.
- Possible applications: From rural areas to urban areas including museums, palaces, temples, etc. Almost all places can utilize it.

In this paper, the proposed system using the concept of hybridwas implemented.

3. Architecture and Implementation of Our System

Fig. 1 shows the organization of the system that includes 1) an Android smartphone, 2) a mobile RFID tag reader, 3) Smart Poster to embed RFID tags, and 4) a backend server that receives and processes the requests from the smartphone.

The process to obtain the information is as follows: 1) A user accesses a Smart Poster using a RFID reader, and then the application will start automatically if it has already been installed. 2) In the start-up screen, the user can run an inventory just by touching a button until the tag information is displayed on a screen. In response to this touch, the application enables the mobile RFID tag reader to scan around. The mobile RFID reader returns the basic information including the tag ID from the RFID tags if the mobile RFID reader succeeds in finding some RFID tags nearby. 3) and 4) The application receives the value and sends it to the backend server through the Internet to request the information stored in the database of that server. 5) The backend server processes the request and searches the related record from the database. Normally, the record consists of information, such as where the tag is (same as where the user is), what the place is for with a simple description, how the area of the surroundings is, or where to go among the points of interest. This information is essential for tourism. 6) The application displays the received information on the screen. The information is shown in a form of list. 7) The user can select one item from the list, and then 8 and 9) the user can see the detailed information from its linked URL.

Using this solution, the user will obtainthe necessary information regarding where the person is and where to go among the points of interest easily without using a GPS or

Table 2. Proposed data structure in this paper.

Essential	key id (just for the key value in the database. not be shown to the user) Tag ID (unique id value of the RFID tag) URLs (URLs corresponding to a Tag ID. Each URL has two forms: full URL; and shortened version of the full URL)
Optional	Title (or something else like simple description)
Extended (not yet implemented, but might be required)	Picture, Text description, Comment, # of Recommendation, and others

tiresome web surfing. Therefore,the data in the database should contain the tag ID and URLs as a minimum. The tag ID is from the RFID tag that is embedded in the Smart Poster. This is used to identify where the RFID tag is, and therefore where the user is. The URLs attached to the tag ID are used for location and navigation for the recommended route. Table 2 lists the proposed fields in the database. Until now, only the Tag ID, URLs and the titles of each URL are stored in the database. The titles of the URLs are inputtedmanually. Detailed information, such as pictures, comments from other users, the number of recommendations, and others, might be added to upgrade the front-end.

Each URL is stored double in the database. One is the full URL and the other is the shortened form of the full URL.

This is because many URL shortener services (such as goo.gl[1] or Bitly[2]) provide statistics related to the number of clicks for the past, referrers, browsers, operating systems, IP based region information, etc.. This may help information providers' insightful metadata for tourism services. For example, the number of clicks can help determine which places are hot. Extra programming and storing data for statistics, however, incurs another cost. Therefore,this studyuseda short URL for statistics. On the other hand, there is one problem. The short URL's destination is not transparent [19]. A long URL (full URL) has much information regarding its destination. For example, consider 'http://www.korea.ac.kr' without actual access. At least three things can be inferred. 1) The top-level domain name '.kr' means that the host country is Korea[3]. 2) The second-level domain name '.ac' indicates that this URL is for a collegeor other academic institution[4]. 3) The third-level domain name '.korea' may refer to the name of the institution. Hence, the URL's destination can be considered an academic institution located in Republic of Korea; it is actually the full domain name of Korea University. On the other hand, the shortened URLs are normally made of a randomly generated meaningless string5. These are known to be vulnerable to cyber-attacks because short URLs work on redirecting the visitors to a previous long URL [20]. The destination may be a spam site or a site with malicious script code. Therefore, to prevent abusing the short URL, it was decided to use both of them in that a long URL is shown to users as an indicator of where to go, and a short URL not shown to the users is the true URL for statistics.

3.1 Interaction between the User and Application

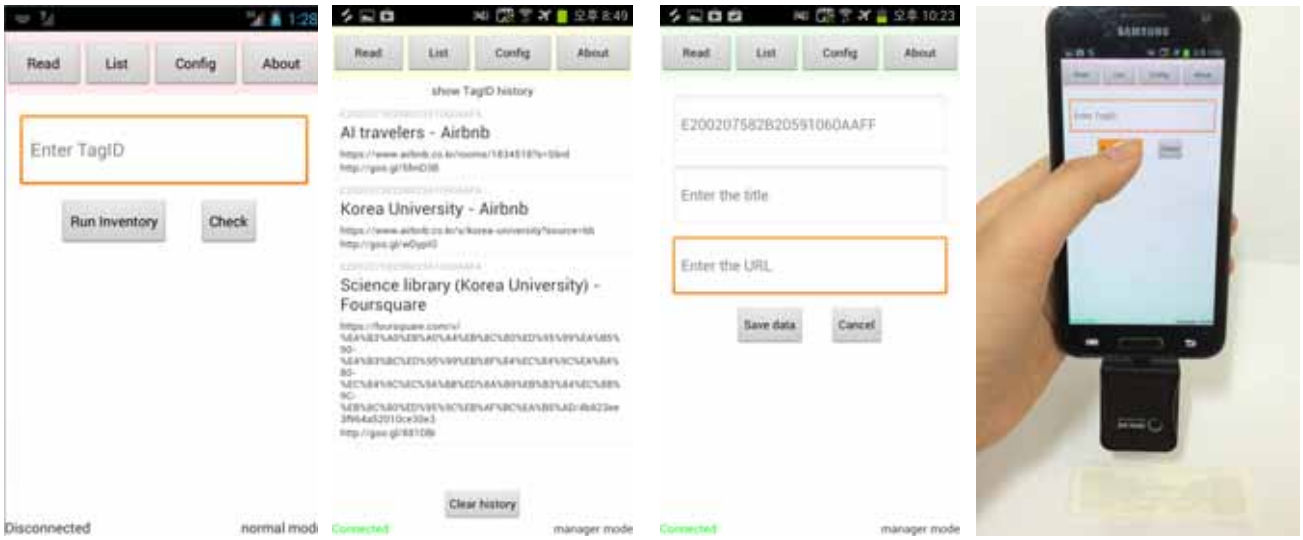
If the user connects the mobile RFID reader to a smartphone, in which the application is pre-installed, the application is activated automatically. If not, a pop-up box will appear on the screen for installation if it is the first time to use the application. If the application starts to execute, the application initially shows an inventory screen. Fig. 2(a) shows the start-up screen. In this screen, the inventory can be run by touching the button constantly. As shown in Fig. 2(a), there is a button for running the inventory that allows the user to obtain the information. While the user keeps touching the button, the application would keep searching and reading the tag ID from the nearby RFID tag(s) as well, through the mobile RFID reader. (Fig. 2(d)). The user can easily notice that the application is scanning RFID tags by visual changesin the button. This RFID tag scanning continues until the user detaches his/her finger from the button. Therefore, even when multiple RFID tags are around the user, these RFID tags can be handled sequentially until all the RFID tags that the user wants to read are scanned. The user can stop searching at any time when he/she doesnot want to scan the RFID tag(s) anymore.

3.2 Interaction between Application and Server

Fig. 3 shows the process flow on the server-side. As soon as the mobile RFID reader reads the tag ID from the tag on a running inventory, the application starts to access to web database immediately, by obtaining the URLs corresponding from the acquired tag ID. The database is in the specified back-end server including DBMS system.

Under the condition of a constant connection to the Internet, the application starts interacting with the backend server to process the result of tag scanning. On the back-end server, there is a server-side script receiver file that receives the request from the application and sends the searching query to the database. After the server processes the request, the server answers the application. If there is any matching tag ID in the database, the matched tag ID, URLs and the titles of the URLs are sent to the smartphone. Finally, the application displays a list of the URLs on the screen while storing the URL scanning history

1 http://goo.gl/
2 https://bitly.com/
3 http://www.iana.org/domains/root/db
4 http://krnic.kisa.or.kr/jsp/domain/domainInfo/krDomainInfo.jsp



(a) Start-up screen (b) Showing history screen (c) Configuration screen (d) Scanning

Fig. 2. Running application screenshots and picture.

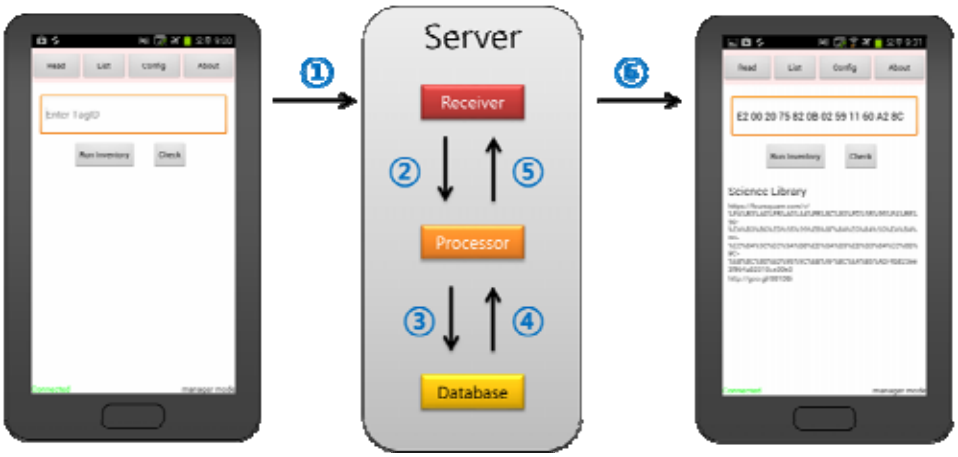


Fig. 3. Server-side processing.

simultaneously. The result of the URL scanning history, as shown in Fig. 2(b), is shown at the 'List' menu.

The configuration menu of the application in Fig. 2(c) is for tourism information providers. First, using sign-in function, some special users, such as service providers, can be authorized as administrators. The indication of a normal user or an authorized user is at bottom right of the screen. The normal user can see the Sign-in button and 'Normal mode' text. The signed-in user can see Sign-out button and 'Manager mode' text. The account data of the authorized user is also stored in a separate table of the database. Second, only for the authorized user, can unregistered RFID tags be handled to register proper URLs. If any RFID tag in Smart Poser is damaged for some reason, changing the physical tags and registering virtual new IDs can be performed simultaneously. This would reduce the managerial steps and cost.

In addition, authorized service providers can add a new URL/title to a tag ID, edit data, or delete data in an application at the scanning history screen. The short touch activates an embedded browser like the tag scanning screen, but the long touch invokes a pop-up menu for management (see Fig. 4). Each of the three managerial works is similar to registering a new tag.

Fig. 5 shows the all processes of the proposed system.

3.3 Interaction between the User and Application Again

Fig. 6(a) shows the information received from the server. Each URL is a link to a web page that contains the location or navigation information. For example, there is a URL; https://www.airbnb.co.kr/s/koreauniversity?source=bb.

This URL is linked to the Airbnb service that shows the search result of accommodation nearby Korea University.

The geographic information and a descriptive web page can be attached to the RFID tag. Another URL, http://www.korea.ac.kr/, which is connected to the official web page of Korea University, is an example. The user will be able to know about what the location is for. The application

Fig. 4. Managing data in application.

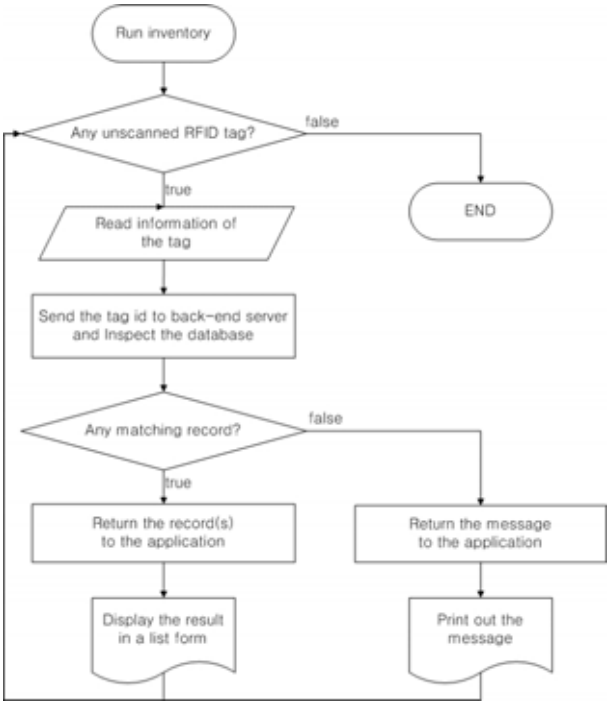


Fig. 5. Flowchart of our system.

(a) Start-up screen (b) Showing history screen (c) Configuration screen

Fig. 6. Running application.

identifies the RFID tag IDs and provides a range of information for the user's satisfaction in this way.

In this scenario, as shown in Fig. 6(b), the user selects an item among the proposed web page URLs, and then the embedded web browser accesses the URLautomatically. The result of selecting an item is shown in Fig. 6(c).

4. Conclusion

A mobile location and navigation system was constructed with minimal effort using existing methods. The location identification was simplified by introducing RFID technology. The navigation and information about the points of interest based on the location identification was extracted from the existing tourism services. The extracted information was then integrated into a single application to reduce the redundant searching process. This was expected to improve the user's experience. In managerial aspects, the change in context does not need to modify the system because the actual information comes from each tourism information service, such as Airbnb, Foursquare, or Yelp, not from our database. The database just has URLs as pointers indicating which web page to go to. As a result, the barrier to entry for users and developers was lowered by suggesting a simple way to obtain useful information for their trip and utilize the RFID technology in the tourism area, respectively.

Acknowledgement

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. NRF-2011-0020128).

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