Smart Cane System: Direction guidance system for the blind using GS1 and EPCIS system

Invited Paper

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ABSTRACT

The Smart Cane System is developed to inform the location for people who are visually impaired. This system adopts GS1 and EPCIS to manage the surrounding information with the standard. The system suggests that the unique key could be collected from the Braille block via RFID and send to EPCIS server to notice the location. The Smart cane sends the key to the mobile application through Bluetooth. The EPCIS server communicates with the mobile application and manages GLN (Global Location Number) key for the location of the Braille block and GTIN (Global Trade Item Number) key for the registered blind. The mobile application receives the surrounding information of the Braille block where the blind is from the server. Using the GS1 key and EPCIS system ensures that the Smart Cane system can be used internationally.

CCS CONCEPTS

• **Computer systems organization** → Embedded and cyber-physical systems → **Embedded systems**; • **Networks** → Network Services

KEYWORDS

Internet of Things, Smart Cane, GS1, EPCIS, RFID

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1 INTRODUCTION

According to the WHO report, 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision in 2014 [1]. There are a lot of mobility assisting devices for the blind people, such as the Braille blocks, white cane, guide dogs [2]. Among these devices, the white cane is widely used to inform obstacles on the way. Also the cane helps to identify protruding blocks called "the Braille Block".

Although the white cane and the Braille block give directions whether to stop or go, it is not enough information to visit the new places. Additionally, the blind cannot recognize whether the information is provided by the Braille or not and hard to find where the Braille is located. Another issue is the Braille located outside is usually dirty and have hygiene problems. Therefore, we suggest the "Smart Cane System" providing detailed location information using existing the Braille block system. Combining the Braille blocks with RFID chips enables "Smart Cane" to receive location information [7,8]. This protocol has possibility to be expanded for global use with GS1 and EPCIS.

In this paper, we will introduce what technologies were implemented to "Smart Cane system" in Section 2. The architecture of this system and components are explained in Section 3. In the following Section 4, the implementation and demonstration of the system are clarified in detail. Finally, this paper will be end with a conclusion in Section 5.

2 RELATED WORK

To communicate between the Braille block and the Smart Cane, the wireless communication technology like RFID, Bluetooth, and NFC shall be used. Because the recognition range of NFC is too short, the blind who uses the Smart Cane may miss the Braille block. In the case of the Bluetooth, it needs continuous power supply, additional steps, and enough time for pairing between the Braille block and the Smart Cane. So, we think the RFID technology is suitable for the Smart Cane system.

2.1 RFID

RFID (Radio Frequency IDentification) is used to identify a unique ID for specific object [3]. In the Smart Cane system, RFID is installed in the Braille block and indicates its installed location. RFID can be used semi permanently and reuse repetitively. Smart Cane used by RFID reader can recognize the RFID tag at close range without direct contact in contrast with NFC.

The RFID Tags and readers communicate by given frequency. Given the type of the frequency, characteristics like recognition range can differ. If the frequency is low, the recognition distance is short. However, in contrast, if the frequency is high, the range becomes long and in relation the usage of electronic power and cost are increased [3,4].

The collected unique key of RFID by the Smart Cane is required to perform a query in the database on the server. It will be discussed in the chapter 3.4.

2.2 GS1 and EPCglobal

The GS1 (Global Standard 1) is international organization to help identify, capture and share information for supply and demand chains [5]. GS1 has opened offices in 112 countries and millions of corporations which are associated with GS1 are currently adopting this as a standard.

Figure 1: GS1 Overview [5].

As in Fig. 1, the GS1 standards show three part of its system - identifying, accurately capturing and automatically sharing information about products, locations, assets and more [5]. Identification defines unique identification codes. The GS1 provides 11 GS1 Identification keys for events and information, and the Smart Cane system adopts two keys as shown in the Table 1. Each Smart Cane has a unique number to identify the blind and their location. The GS1 Key for the Braille block represents where the block is located. The Smart Cane captures the GS1 Key of Braille Block and shares it to the server which has the database of the information of the user's surroundings.

The EPCglobal (Electronic Product Code global) is the system for the GS1 identification using RFID [6]. Through this system, the information of the products can be shared globally. The EPCglobal requires the standardization for identification key and exchange interface. The standardized data is captured and filtered, grouped by event capturing system like mobile application. Finally, the EPCIS-level events are transferred to EPCIS server and stored and shared. So, by applying the EPCglobal system, the Smart Cane system can be established for the global blind guidance standard. This can be used for the other field like local information system.

Table 1: Two GS1 Identification Keys in the Smart Cane System

ID Key		Used to Identify	Example
Global Trade Item Number	GTIN	Products and Services	Registered Smart Cane
Global Location Number	**GLN**	**Parties and locations**	**Location of Braille Block**

3 ARCHITECTURE

3.1 System Overview

The Smart Cane system is the blind guidance service. When the blind walks along the Braille block using the cane, they can get the voice information of their route like Fig. 2.

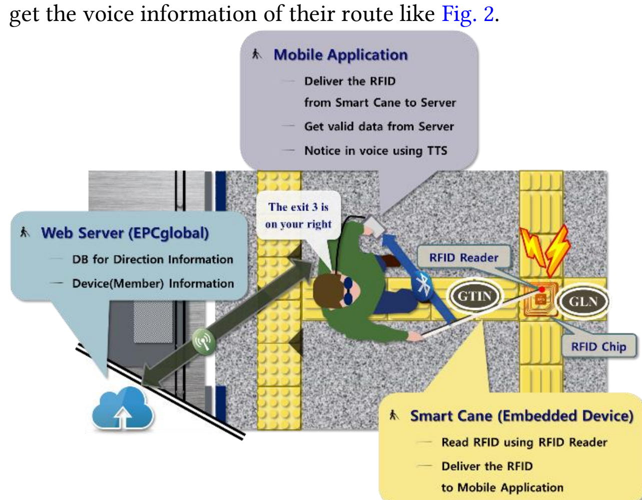


Figure 2: The guide system for the blind using RFID and its components

The Braille Block has its own key for the location at the installed RFID chip. The Smart Cane can capture the key of the Braille block using RFID reader and send to the blind's smartphone via Bluetooth technology. The smartphone will then send the key of the block and the cane to the server and receive the data of the surrounding. In doing so, smartphone application refines the data and notifies to the blind by voice.

As the GS1 system and RFID system, the Smart Cane consists of three parts as shown in the Fig. 2. The Braille Blocks are identified with unique RFID using GLN. The Smart Cane captures RFID and delivers it to the mobile application. The mobile application connects to server to get the valid information and shares it.

3.2 Modeling

The Smart Cane service captures the blind's behavioral events and we defined them as Table 2. The event type is ObjectEvent since it captures sensing data. Action is ADD because it accumulates the events. bizLocation ID is made out of block RFID and geo extension has the block location. bizStep is defined as collecting since our system collects the user tagging events. StickId and ActualLocation are extended features. It represents mobile ID (Android) and actual user location respectively.

Table 2. Example of modelling user behaviour event

EPCIS Event	Event Type	ObjectEvent
	Action	**ADD**
WHEN	EventTime	2015-12-09T15:16:35.880+09:00
WHAT	epcList	urn:epc:id:sgtin:8809421.862511.001
WHERE	bizLocation	urn:epc:id:sgln:8809421.862513.200
	geo extension	37.48442, 127.0340
WHY	bizStep	urn:epcglobal:cbv:bizstep:collecting
Extension	StickId	622669b92134af6e
	AcutalLocationLat	37.481907860365936,
	AcutalLocationLng	127.04296946525574

Our XSD is defined as above schema. Stick ID's type is restricted to integer. Each stick position's type (latitude, longitude) should be double since it represents Geo location information. Finally the mobile ID's type is string since it contains Android mobile ID. Following is the Example of a XSD for user behavior event.

```
<xs:schema xmlns="http://tempuri.org/XMLSchema1.xsd"
xmlns:matns="http://tempuri.org/XMLSchema1.xsd"
xmlns:xs="http://www.w3org/2001/XMLSchema"
id="XMLSchema1"
targetNamespace=http://tempuri.org/XMLSchema1.xsd
elementFormDefault="qualified">
  <xs:element name="StickId">
    <xs:simpleType>
      <xs:restriction base="xs:integer"/>
    </xs:simpleType>
  </xs:element>
  <xs:element name="StickPostionLat">
    <xs:simpleType>
      <xs:restriction base="xs:double"/>
    </xs:simpleType>
  </xs:element>
  <xs:element name="StickPositionLng">
    <xs:simpleType>
      <xs:restriction base="xs:double"/>
    </xs:simpleType>
  </xs:element>
  <xs:element name="MobileId">
    <xs:simpleType>
      <xs:restriction base="xs:string"/>
    </xs:simpleType>
  </xs:element>
</xs:schema>
```

In event capturing, first, the mobile fetches the Block RFID through Bluetooth communication. Then it captures the current location information with GPS sensor (android.location API) followed by getting an android ID. Finally it constructs an XML out of its data and sends it with Http POST method to EPCIS server through OkHttp library, which Square Inc. has developed. The source code is widely accessible.

4 IMPLEMENTATION & DEMONSTRATION

4.1 The Braille Block with RFID

Normally, the "Stop" Braille block is installed at the fork or used as a guide to warn. So, only the "Stop" Braille block is identified with a unique GLN key using RFID. This GLN key locates where the blind who touches at that Braille Block using the Smart Cane is. Also, the key is used to give useful information about what's around that Braille Block.

In this system, we choose LF 125 kHz with consideration for range and size. If the frequency is increased, the RFID chipset size is also bigger and expensive. On the contrary, if the frequency is decreased, the Smart Cane cannot recognize the RFID chipset installed in the Braille block.

4.2 Embedded Device: The Smart Cane

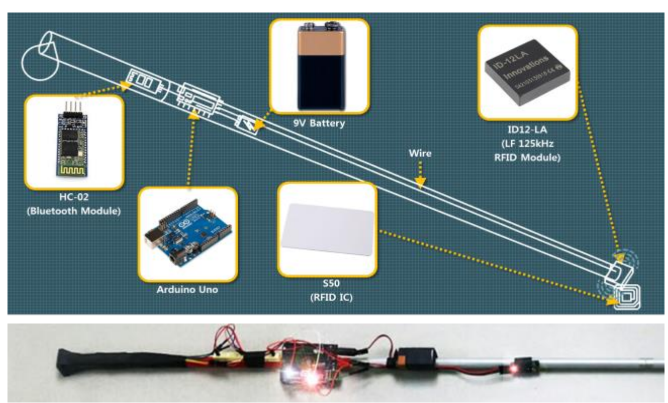


Figure 3: The guide system for the blind using RFID and its components

We make the Smart Cane using the Arduino with RFID reader and Bluetooth module. At the end of the cane that touches the ground, the RFID reader is installed, in which will then capture the key of the RFID chipset. When the cane get a new GLN key from the block, it delivers the key to the Mobile Application via Bluetooth. We chose the Arduino Uno for the embedded board because it's cost efficient and spends low power.

Each Smart Cane has its own GTIN key, which represents the unique ID of the blond. With this GTIN key, the Smart Cane system can trace the path of the specific blind.

4.3 Mobile Application

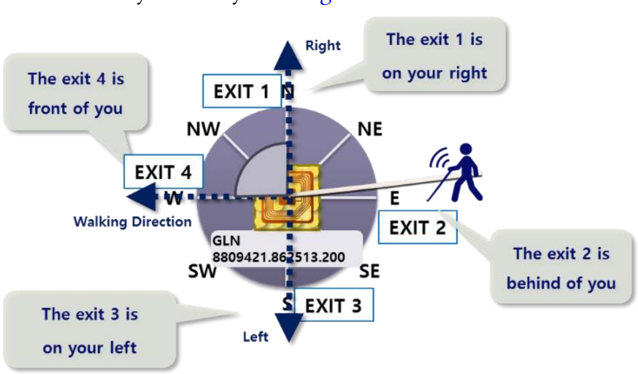
The mobile application pairs with the Smart Cane device using Bluetooth and registers the blind using GTIN key at the EPCIS server. The user of this mobile application is blind, so we make its UI simple in order to provide convenience for the user to handle the application. The mobile OS like iOS and Android has accessibility feature to help the blind using voice assistant, so that the blind can pair between the Smart Cane and the Mobile device easily.

When the Mobile Device receives the GLN key of the Braille block from the Smart Cane, it queries to server to get the local information represented by the key. The local information indicates what is around the blind. The Table 3 is the example of the local information based on the four cardinal points.

Table 3: The ScInfo table's schema

ID	UUID	N	E	S	W
PRI key	GLN Key	North side	East side	South side	West side

After the receiving the local information from server, the mobile application will get the information where the blind is headed using the magnetic sensor and the acceleration sensor in the mobile device. Using the walking direction which is gathered by magnetic sensor, mobile application calculates the direction information dynamically as in Fig. 4.



ID	UUID	N	E	S	W
01121321	8809421.862513.200	EXIT 1	Exit 2	Exit 3	Exit 4

Figure 4: Calculating the direction information using GLN key and local information.

Finally, the TTS(Text to Speech) system of the mobile OS, it notifies the direction information to the blind by voice.

Figure 5: The mobile application of Smart Cane and execution the TTS service

4.4 EPCIS Server

The EPCIS server stores the GLN and the local information like the Table 3 as the master data. It accumulate events like the when, where and which Braille is captured by the Smart Cane. It also records which Smart Cane has passed which specific Braille Block. When the Smart Cane is registered on the server, it would record as the transaction data.

Those data can access globally, so the blind can get the local information regardless of the country.

4.5 Demonstration

We decided to do a demonstration on the way inside the subway station. Because the Braille block is installed well and it's easy to clarify the direction. We decide 4 points and made Table 4 with information related to the exit. With this information, we tested to find the exit 4 from the faregate just bank on the TTS guide. The test movie is at https://youtu.be/uLoLjlXAKhk. (The TTS in the movie speaks in Korean.)

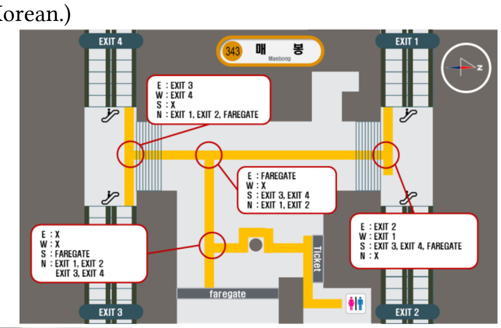


Figure 6. The Map for the demonstration (at Maebong Station, Seoul, South Korea)

Table 4. The partial database for the demonstration

ID	UUID (GLN)	N	E	S	W
0001	4567 1234 0001	EXIT1 EXIT2 EXIT3 EXIT4		FAREGATE	
0002	4567 1234 0002	EXIT1 EXIT2	FAREGATE	EXIT3 EXIT4	
0003	4567 1234 0003	EXIT1 EXIT2 FAREGATE	EXIT3		EXIT 4
0004	4567 1234 0004		EXIT2	EXIT3 EXIT4 FAREGATE	EXIT 1

5 CONCLUSION

From our field trial, the Smart Cane system is helpful to the blind in giving the information of direction. If we adopt and expand the system of ONS and EPCIS, the Smart Cane system can establish as the global standard for the blind. The local information is managed by the server of each country. When the blind travels to another country, they can get the information of the direction in the voice of their own language.

There are some parts to improve. It needs to receive feedback from the blind about using the Smart Cane system, and also how to make the device simple and easy to use. Most important point is the consideration of RFID system. The rate of recognition must be increased for actual situation.

The systems that notice the local information can be combined with navigation system. The Braille block which installed the RFID chip can connect the route for the destination that the blind person wants to go to. Managing the local information using GS1 and RFID system will become an inexhaustible resource.

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