Shopping Navigation Assistance System on Android Using RFID Applications and Dijkstra's Algorithm

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***Abstract*—This research aims at developing a model of indoor route guidance with RFID technology to identify users (customers) and product locations by using a mall as a prototype for a Data Warehouse. The researchers have designed a set of RFID devices, which store and read product locations and also communicate with applications. The route guidance system was developed in the form of applications on Android operating system, where users can search for desired products. The system then guides the customer using Web Server transmission. The system gets a product list from the customer and displays the path, which guides the user to the locations of selected products.**

Results from the application tests of the RFID technology for navigation on Android within a local mall showed that the system can display the selected items and recommended routes to the various points correctly. However, this is only a prototype. For realistic operation, it needs better performance by modifying the set of RFID devices to improve the speed and distance of reading and transmission of data.

***Index Terms*—Route Guidance System; Mobile Computing; Android Operating System; Smart Phone; RFID Applications; Information Technology; Data Warehouse; Algorithm.**

I. Introduction

At present, trade and shopping malls are growing, leading to an increase in commercial competition not only on a global basis but also within regional communities. Besides unique selling positions, other competitive advantages can be enabled with the help of technology by business competitors and can help build profitability and survival of their businesses. The key factors of business are to serve the customers of the mall impressively and to suggest and help them find products quickly during the rush hour. The malls typically use labels to signpost the type or category of products in each block, but not all other items can be listed in such a way.

The items in the mall, some of which may not be aligned at the same location, may need to be transferred to different positions to put all the items depending on current promotion policies of the mall. Customers in the mall usually search for products by category or tags and categories to recognize the product position and location. As a result, customers sometimes find it difficult and confusing to locate the products they need because the products in a mall consist of a lot of items and each block has its different types and sizes.

In this research, we have developed a Shopping Navigation Assistance System (SNAS) on Android using RFID Applications and Dijkstra's Algorithm [1] as a tool to facilitate the customers finding product locations and positions faster with the easiest route guidance.

II. Literature Review

In recent years, several indoor navigation systems applying different technologies have been developed. In most cases RFID powered navigation systems focused on providing assistance to visually impaired people [2], [3], [4], [5].

A navigation system for a patient in the hospital with RFID [6] has helped the blind and deaf to navigate paths within the hospital. As usual, navigation systems in hospitals are a signpost to various locations. The way using the labels is not easily accessible to the visually impaired who cannot read the text. RFID has been applied as a tool to tell the coordinates of the location. The system is divided into two parts: the software and the device with RFID. The software supports interaction with the database used to calculate the best route from source to destination and displays a map to indicate the current position of the stick RFID Tag. Also, part of the display can be presented in the form of voice or text along with the map. To create a network of individual RFID Readers are used together with a microcontroller system that interprets the signals coming from the sensors and RFID. A voice recording locations by routing system is capable to tell visually impaired people how to go. In addition to the facilities to the visually impaired and able-bodied, the system is available in case of lost track of navigation because the route to the location within the hospital is too complex to reach. Several routes used apply Dijkstra's Algorithm to calculate the shortest distance between different places. The system automatically selects the shortest path for users to facilitate faster travel to places.

Eelker [7] has developed a navigation system called Navatar which can be used indoors for the visually impaired. It can be used on smart phones and the Navatar standard navigation system is different from the current navigation systems which require expensive sensors and are too heavy. Including hallways inside the building, it is necessary to install a radio transmitter which sends signals to the handle held to find the user's location. That is why the original navigation system in the building is used less, while the Navatar uses data architecture map in every building, a sensor which is available on the smart phone, a compass or speedometer to help in detecting, locating and guiding the user in every step to find the right path. In addition, the Navatar also confirmed the position of the user with voice, which can facilitate the users to carry the phone in a pocket and walk using a stick for the blind and respond with a hands-free system. The Navatar can be used in other environments, including outdoors in conjunction with the navigation system and satellite navigation systems.

Namahoot and Brückner [8] have developed a location-aware Smart Phone Emergency and Accident Reporting System (SPEARS) for Facebook and Twitter users including agencies responsible for handling emergency situations and accidents. Agencies (e.g., police, fire departments, and hospitals) can store their locations via SPEARS, so that users involved in an emergency situation can retrieve the shortest path from the point of alert to the point of care, e.g. a hospital. On the other hand, agencies can retrieve the current location of an emergency via GPS and send help immediately. The shortest path is calculated by applying an improved Dijkstra's algorithm [9] and displayed on Google maps in appropriate scaling.

III. System Architecture

The system architecture design (Figure 1) can be described as follows:

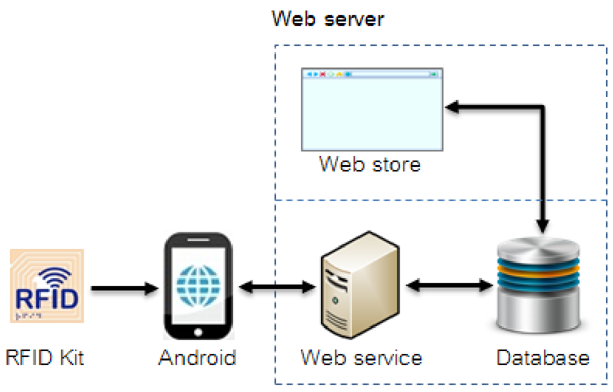

Figure 1: System Architecture Design

1. The RFID Kit is used to identify the location of users or customers on routes within the mall, which consists of three parts:
   - RFID Reader is used to read information from RFID Tag
   - RFID Tag stores the reference numbers of the RFID position and product blocks; then, RFID Tags will be installed at various points on the route inside the mall
   - IOIO OTG is used to transfer data between the RFID Reader and smart phone (Android operating system); for testing the device, RFID Reader and IOIO OTG can be installed on a cart.
2. Smart phone (Android operating system) is a user device that has SNAS installed before use. The system receives information sent from the RFID devices and sends data to the Web Server to display and interact with the user in locating products and suggesting the shortest routes to customers.
3. Web Service is a part of Web Server, which receives the item locations that are sent from mobile smart phone (Android) and then calculates the shortest routes and displays them on the user or customer device.
4. Warehouse Management System (Web Store) is used to manage a warehouse database by the administrator who can change, add, delete, edit data items, and RFID location information.
5. Warehouse Database is to store and maintain the item list and RFID location, which can be used with the recommended route inside the shopping mall.

The RFID kit is designed to identify the user's location and the reference position of item blocks for the shopping navigation system inside the mall. The device includes the following tools:

- RFID 13.56 MHz Read/Write Mifare Module (I2C)
- MIFARE 1K RFID LABEL 13.56 MHz
- IOIO-OTG
- Super Mini Bluetooth 2.0 Adapter Dongle
- Power Supply 5500 mA 5 V

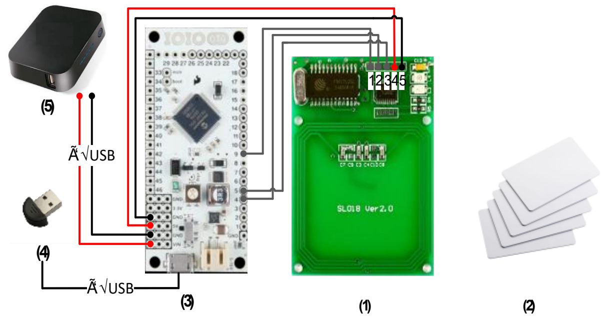

Figure 2: The connection of RFID kit used in shopping navigation system

RFID Tag position design and installation are used to identify the location data of products in SNAS, which can be stored in the Web Store. In the design, the researchers determined position to form a map using vertical (axis x) and horizontal (axis Y) axes. The vertical takes a letter of the English alphabet as the title (A-B-C) and the horizontal is represented by numbers in the order form. For example in Fig 3, C4 is a position that is aligned to match C and 4 in the vertical and horizontal position, respectively. RFID Tags can be installed onto a path at a junction and in the direct path, which can be spaced evenly throughout the path and must cover all the item blocks arranged for its precise navigation to the product. This can reduce costs by installing RFID Tags.

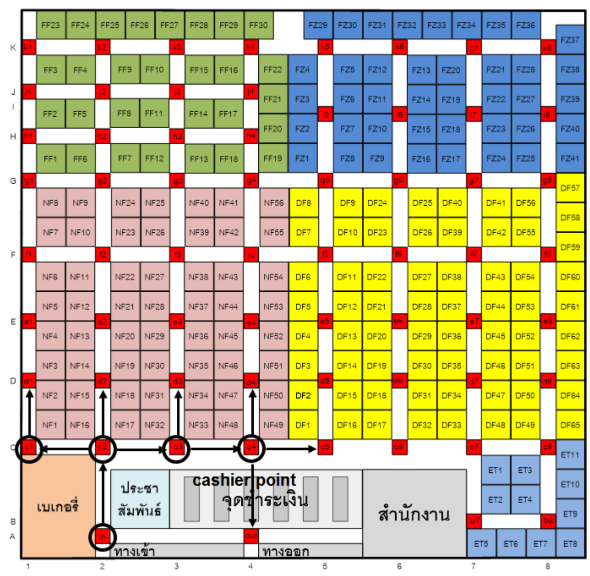

Figure 3: Routing storage and placement of RFID

SNAS consists of six databases, as shown in Figure 4.

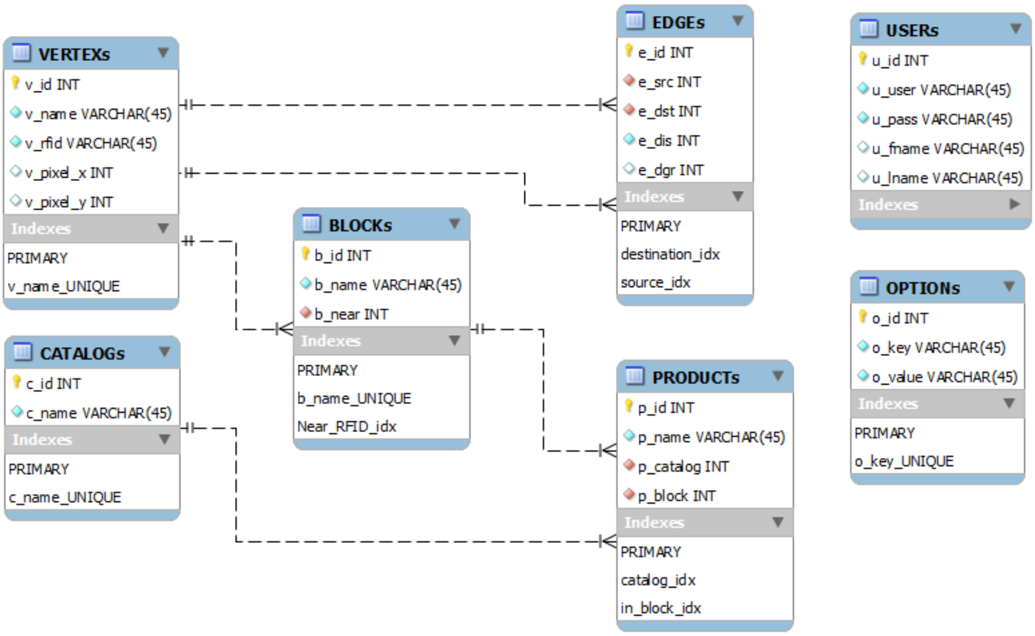

Figure 4: ER-Diagram of the system

IV. System Implementation

The objectives of this paper are:

1. to create a navigation system inside the mall through an Android smart phone, and
2. to apply Dijkstra's Algorithm for calculating the shortest path within the mall, and 3)
3. to apply RFID technology as a tool for identifying and displaying the user's location on the route within the mall.

In this research, PHP language is used for developing the Data Warehouse management system, and MySQL is used for setting up the storage warehouse.

A. System Process

The user interface provides descriptions regarding the application process, which consists of two levels according to user roles:

1. Users/Customers
   - need to be a member of the mall in order to use the system.
   - need to have Android smart phones, which can connect to the Internet all the time.
   - can search and select or type in a list of desired products.
   - can search for the shortest route for shopping inside the mall
2. Administrators
   - Can add, delete and modify general information about details and location of a product keeping it up-to-date in the data warehouse

The overall system process has been implemented as follows:

- Show list of products after customers search for or type in a list of desired products.
- Check duplicate chosen products after customers select products to buy.
- Delete the duplicated products and add customer products to the shopping list.
- Check all positions of products from the shopping list and return product locations.
- Navigate customers to the product locations with the shortest route.
- Recalculate the shortest route when users change the list of products or go to other directions (wrong direction).
- Check the last position as the cashier point (payment), then terminate the navigation process.

B. Dijkstra's Algorithm

In this paper we have applied Dijkstra's algorithm [9] as it has been used for SPEARS [3] and which can be described as follows:

Let the node of customer's location be the initial node and let the list of buying items be the target node and the cashier position is an ended node. The system determines the payment (cashier point) to an end in the navigation at all times. First, the system checks all location of nodes, distances and paths between the initial node to the target node and ended node from a database. All nodes can be calculates the shortest path using the Dijkstra's algorithm described in the following:

1. Set initial node to zero (current node) and all other nodes to infinity (unvisited nodes).
2. For the current node, find all unvisited neighbors and calculate their tentative distances. Compare the newly calculated tentative distance to the current assigned value and assign the lowest one.
3. Insert the lowest node into the visited path and set it as the current node.
4. Select only unvisited nodes and go back to step 2 until the target node has been visited, then terminate algorithm.

5. Get the shortest path from the initial to the target nodes and ended node with the smallest tentative distance of target node.

V. SYSTEM TESTING

We have tested the system in a major shopping mall in Phitsanulok Province, Thailand, and used it to navigate customers for shopping, especially during the rush hours. The users must type in or select products they need before using the shopping navigation system. The interface of shopping navigation consists of two main screens (see Figure 5):

The map of product locations is used to display a map of the mall and current customer position inside the mall with shortest route to the list of products

Direction guidance is used to navigate to the list of products step by step. It describes the details of the route, such as turn left, turn right, walk straight to show the distance it takes to travel. The system will alert when the customers walk or struck the wrong path and calculate a new route.

Figure 5: Interface of the system

The system testing on navigation has been divided into four test steps as follows:

1. Navigate to the product according to the user-defined number of products.
   In this case, the user defines a list of six items, such as, soap, powder, perfume, cleansers, apples, and markers. Then, the navigation system calculates the shortest route and guides the user to travel in order to get all products they need inside the mall. An example of the shopping navigation can be seen shown in Figure 6.
   Figure 6 shows how the system navigates customers by correcting directions of the desired products (soap and powder). The arrow represents the directions (left, right, straight), and the map represents the location of the desired products and how to reach them on the shortest route.
2. Navigate to the products which are located in the same block arrangement.
   In this case, some products are located in the same block position. The system displays these products in the same line of navigation list. Figure 7 shows that mosquito repellent and pest powders are in the same product block.
3. A user has not followed the shortest route or goes in the wrong direction.
   In this case, the system checks the correct position and displays a warning message "wrong direction" (Figure 8); the user then can return to the previous purchasing location. However, if the user does not want to go back to the original route, then the system checks all the remaining products and calculates the new shortest route for him/her.

Figure 6: The shopping navigation Interface on Android both direction and a map of product location

Figure 7: Navigate to the products which locate in the same block arrangement

Figure 8: The navigation system displays a warning message "wrong direction"

4. There is a change in the product list while the system is navigating.
   In this case, users want to edit the list of products by adding, deleting or changing items, while the system is navigating. The system then cancels navigation to all remaining products and keeps the list of items up to date and recalculates the new shortest route.

VI. CONCLUSIONS AND FUTURE WORK

In this paper, we have reported on the results of a create-and-design research aimed at providing a Shopping Navigation Assistance System (SNAS) on Android using RFID Applications and Dijkstra's Algorithm. This system provides customers with the guidance to locate and navigate their individual list of products, and by applying SNAS they are able to find the shortest route to the desired products and their locations. The system tests showed that the functional requirements are met. However, there are some problems in terms of distance limitations of reading RFID Tags. In future versions of SNAS, we plan to improve the system by expanding the size of the antenna of the RFID Reader to be able to read RFID Tags at longer distances. The system will also allow customers to input product lists by speech and Optical Character Recognition, respectively.

Moreover, it might be worthwhile to study indoor route recommendations based on the real-time flow of pedestrians (customers) populating the environment as has been proposed in [9].

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