Location Technology-Based Mobile Shopping Service System

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Abstract

In this paper, we propose a novel location technology-based shopping service system (LSSS); describe its design methodology and implementation detail. LSSS incorporates handheld terminals, resource management system and wireless location technology together to make a whole system. The service provided by the system can make customers in a shopping mall conveniently get product information, notice their current location, figure out proper shopping route when multiple choices are in the shopping list, obtain the navigation information and receive other related innovative services. The successful case experiments proved the feasibility of LSSS in real shopping practice.

Keywords: *Mobile Service; Wireless Location Technology; Shopping Mall*

1. Introduction

Most resource and information management systems in shopping malls today provide only relatively simple information queries and commodity management services without personalized customer service. In field of electronic shopping guide, they can only provide static information services; no interacting experience for the customers. In addition, due to the fact that the internal structure of a large sized shopping mall is usually very complicated, and thousand categories of goods are presented, there is increasingly complex information for a customer. Moreover, since there is lack of effective means of real-time feedback to the server side data processing system, it is quite complex to let the management system and the customers exchange information dynamically. Currently, most reports of "smart shopping" system still focused on basic information platform built via SMS (short message system), Website and other means to push sale information to attract customers. Due to the lack of interaction, such information platforms have serious shortcomings. For instance, members may not notice the messages, or the information is never used even if customers receive the messages. Furthermore, customers cannot get detailed shopping instructions, because these systems communicate with customers by transmitting static information such as texts and pictures, which can hardly express the shopping experience effectively.

The rest of this paper has been organized as follows. Section 2 gives some related work about shopping mall service systems. In Section 3, we describe the design methodology and functionality modules of LSSS in detail. In Section 4, we present the result of case experiments for LSSS. Some concluding remarks are included in Section 5.

2. Related Work

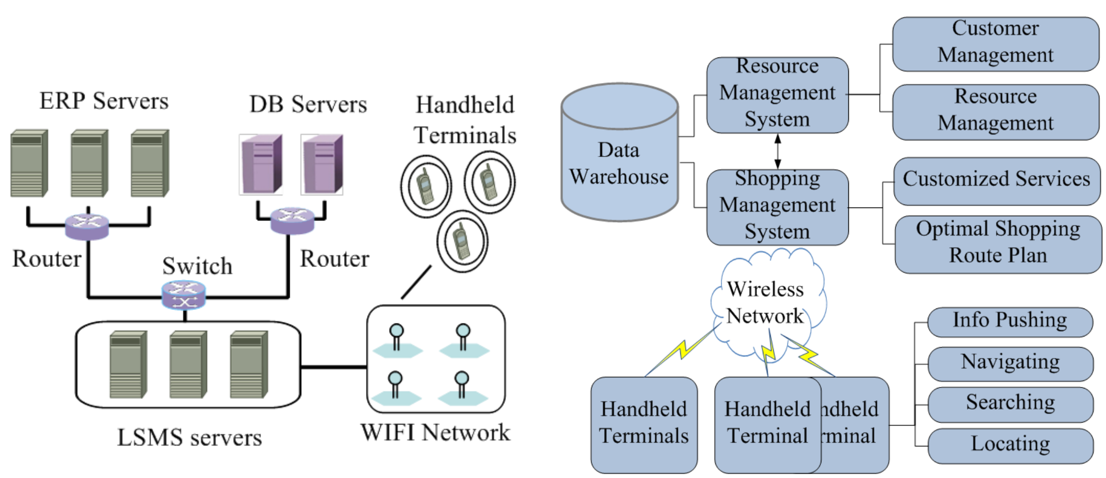
To realize information interaction between customers and shopping malls, RFID technology began to be adopted in the smart shopping system [1]. By using of RFID tags and readers in our proposed system, it's convenient for customers to find their goods in the shopping mall. However, its disadvantages are also very obvious, such as the significantly increasing cost by using customer terminal integrated RFID reader, and the difficulty of label arrangement because it may bring about many problems like label collision [2]. However, with development of hardware, WIFI or Zigbee based positioning system, have been proposed [3, 4]. These systems have laid a solid foundation for smart shopping. The locating technology based shopping system proposed in this paper was built upon RSSI-based ranging techniques [5, 6].By setting up a small number of signal transmitters and performing some distance measuring calculations, the system build a wireless network which can realize the real-time customer locating [7] in the mall area without arrangement of many RFID tags and Readers. Meanwhile, the resource management system of the shopping mall is incorporated with handheld terminals of the wireless network, thus goods information, smart shopping guide and other innovative services can be realized.

3. Design Methodology of LSSS

The design methodology of LSSS is presented in this section. First we describe the overall design of the whole system and the network topology for a typical deployment; then we describe the functionality modules of the system, including the design of handheld terminal, the locating service and shopping route planning service.

3.1 Overall Design of the System

The LSSS consists of hand-held terminal systems, shopping management system and resource management system, as shown in Figure 1.(B), and a typical network topology for system deployment is as Figure 1. (A):



(A). LSMS network topology **(B).** LSMS logic block diagram

Figure 1. LSSS System Architecture

3.2 Hand-held Terminal

To facilitate the process of conducting the experiments for evaluating the functionalities of LSSS, we customized the handheld embeded systems. The design objective is to build a similar computing platform as regular mobile device such as an intellegent mobile phone and development and test enviroment for client side software system. However this experimenal device is not a required client to obtain the LSSS service. As most of the services are provided by the server side applications, the client is to receive the calculated result sent back from LSSS server and render the corresponding interface to the user. Thus, for the real deployment enviroment, the handheld device can be replaced by an Android, iOS or Windows Phone device that running the client software. As to the experimental handheld terminal system, it includes the handheld device hardware and software system. It is used to communicate with LSSS server of the shopping mall, and provide customers with the services. As shown in Figure 2, the experimental hand-held terminal is built by using TI's OMAP3530 EVM development board. The board has a 3.7 inches VGA / QVGA LCD touch screen, the OMAP3530 processor(720MHz ARM Cortex-A8/520MHz C64x + DSP) for speed optimization, 256 MB LPDDR/256 MB NAND flash memory, 10/100Mbps Ethernet , SDIO, I2C, JTAG, keyboard and WIFI module.

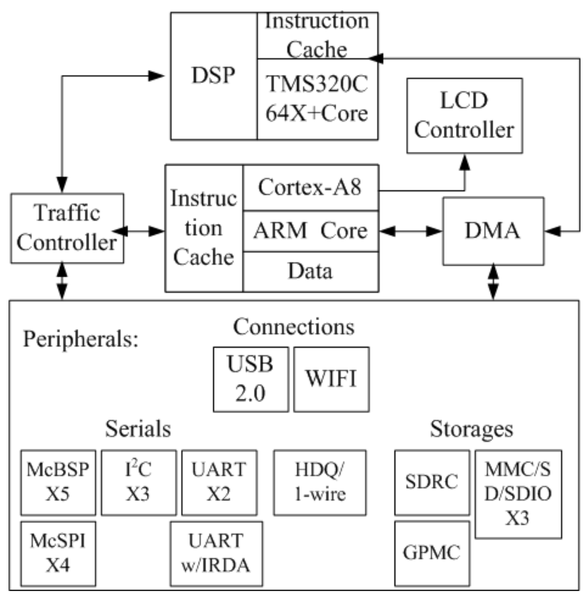


Figure 2. Experimental Terminal Device Block Diagram

The client side software system is built on an embedded Linux system, the simplified workflow of hand-held terminal software is shown in Figure 3. The software system work interactively with LSSS server, to provide users the major service functionalities as described in the following sections.

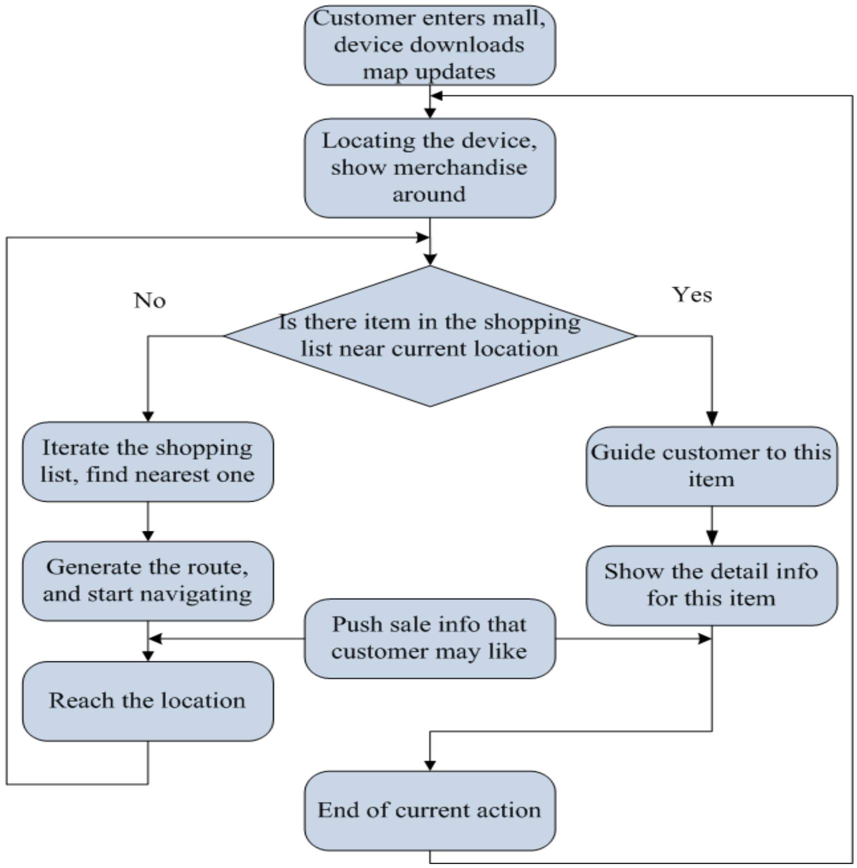


Figure 3. Simplified Work Flow for Client Device

3.3 Customer Locating Service

Once a customer enters the shopping mall, the hand-held terminal will download up-to-date map from LSSS server. Locating module automatically locates the nearest source of a number of communication nodes to figure out the customer's current location, and display the location. To make wireless access points cover as great range as possible, we put these nodes right below the ceiling height, and reverse the antenna (which can be spread out down the signal) as described in the literature [8]. An experimental floor plan is shown in Figure.4. This deployment can not only minimize the signal absorption of the ceiling and the floor, but also the degree of interference. While the customer's handheld terminal work in shopping area that is cover by the wireless access points, the location module will periodically send location request to the surrounding nodes and receive location information as shown in Figure 5. The received location information will be converted into the customer's coordinates by using the following algorithm, then the generated coordinate information is sent to LSSS server to support other services.

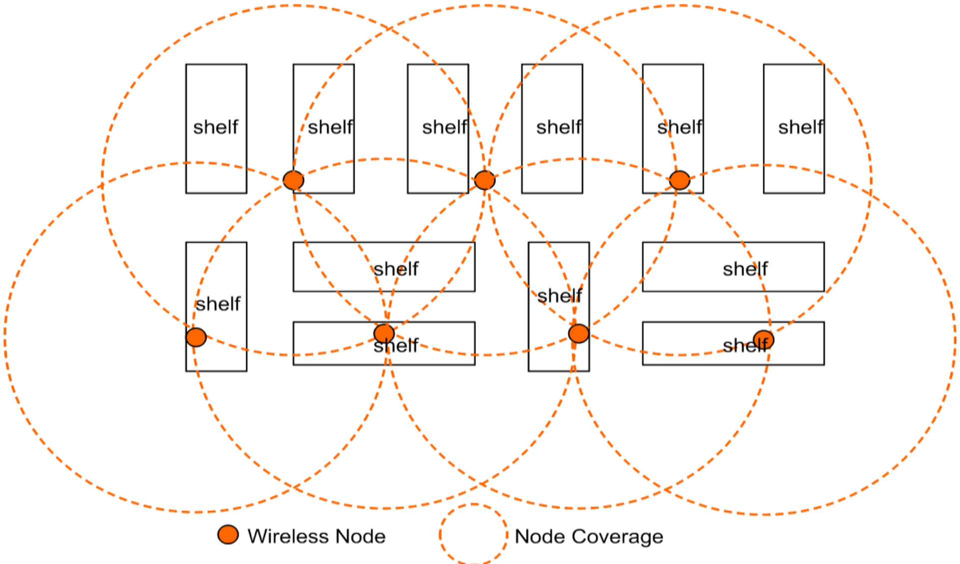


Figure 4. A Typical Access Points Deployment

The customer's coordinates will be obtained as the follows:

1. Determine the distance between the access point and the terminal by eq.(1)

$$P_{R_x} = P_0 - 10n\log\left(\frac{d}{d_0}\right) \quad (1)$$

where P_0 is the received power at a distance d_0 from the access point, d is the distance between the access point and the terminal and n is a parameter, which models the behavior of the environment. [9]

2. Determine the coordinates of the terminal

By using the geometrical calculation, the distance between reader i and the object is identified, i.e.

$$d_{i,0} = \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2} \quad (2)$$

where i = 0; 1; 2; . . . ; n. Considering 2 access points [$(x_i; y_i)$ and $(x_j; y_j)$] and the terminal$(x_0; y_0)$;

$$x_0 = \left(d_{i,0}^2 - d_{i,0}^2\right) - \left(y_i^2 - y_j^2\right) - \left(x_i^2 - x_j^2\right) + 2\left(y_i - y_j\right)y_0 \Big/ -2\left(x_i - x_j\right) \quad (3)$$

Sub (2) into equation formulated by access point (x_k, y_k), we get

$$y_0^2 + \frac{2(2(x_i - x_j)x_k 2(y_i - y_j) + 2(y_i - y_j)A - A^2 y_k)y_0}{(4(x_i - x_j)^2 + 4(y_i - y_j)^2)} + \frac{A^2 + 4(x_i - x_j)x_k A - 4(x_i - x_j)2B}{4(x_i - x_j)^2 + 4(y_i - y_j)^2} = 0 \quad \textbf{(4)}$$

where $A = \left(d_{i,0}^2 - d_{j,0}^2\right) + \left(y_i^2 - y_j^2\right) - \left(x_i^2 - x_j^2\right) \quad B = d_{k,0}^2 - y_k^2 - x_k^2$

By solving the Eqs. (3) and (4), the exact locations of a terminal is identified. The location information is then sent to LSSS server to support other services.

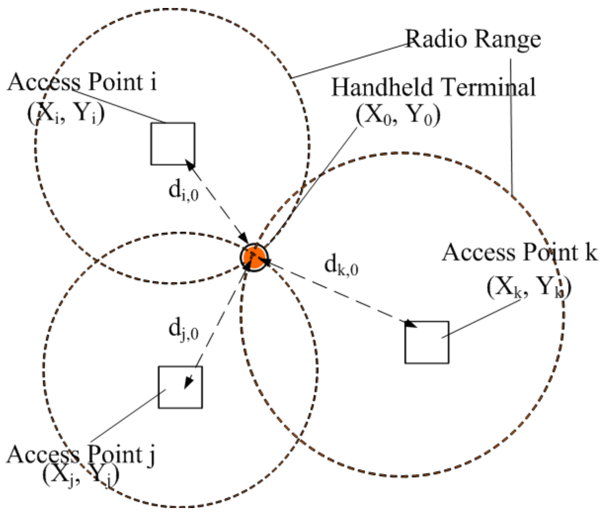
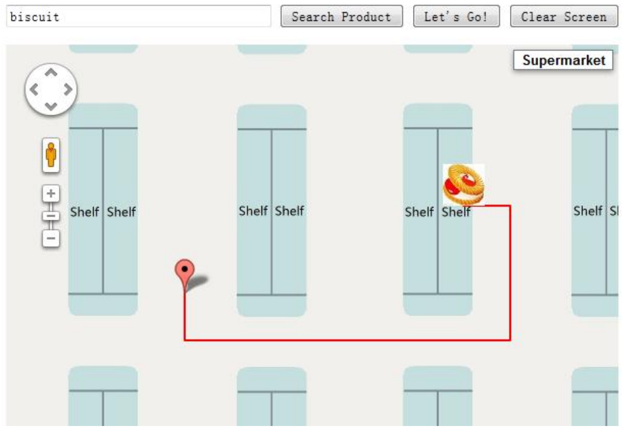


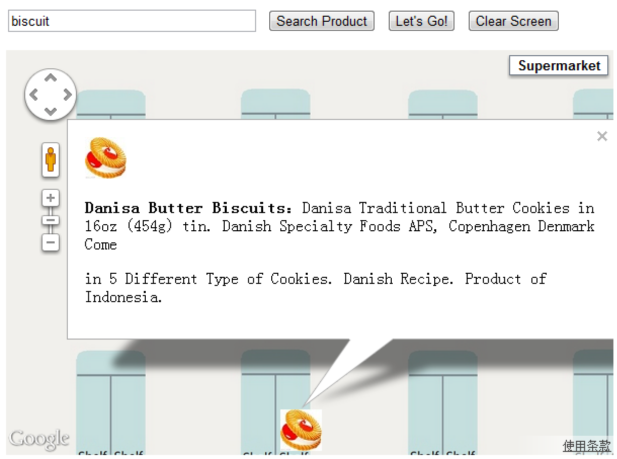
Figure 5. Identification of Terminal Location

3.4 Shopping Route Generation

When a customer is looking for a product, he can input the product keywords to search; the device will then send a request to LSSS server, and then the server returns result list for the customer to choose the items he's looking for. Once the customer pick a product in the result list, the device will send a request for navigation route to the server. Based on the customer's current coordinates which is obtained as described above, the coordinate of the target product in the mall, the LSSS server will calculate the shortest route by the well known Dijkstra's algorithm and send back to the hand-held terminal. Also, as the customer may choose multiple items, LSSS will produce every possible shopping route. Thus, in the adjacent nodes of a shopping route, two nodes may be linked directly, or through other nodes. Based on the shortest path matrix, LSSS will figure out total distance of each route, then select the one with the shortest distance to be the recommended shopping route annd send it back to terminal. Once the terminal gets a shopping route, it will render it based on the stored map. As we hadn't put much attention on the algorithm efficiency and not considered the customer traffic impact on the route determination, further research can be conducted here to make the navigation route decision better.



(A). User Interface for Route Navigation



(B). User Interface for Merchandise Information Display

Figure 6. User Interface for an Experimental Case

3.5 Other Services

LSSS can provide other innovative services based on previous functionalities too. For instance, when customers pass through promotions or discounted merchandise on the shelves, the hand-held terminal will remind customers of these discounted goods. Promotional information can be generated once within a specified time on the screen of the hand-held device to prevent from generating redundant information due to the fact that customers may repeat passing through a shelf. LSSS can also provide convenience and security-related services. For instance, when the customer pressed the help button of hand-held terminal, the system can inform the customer's location periodically to the mall staff so that they can come and give a help. When fire or other emergency situations happen in the mall, LSSS can broadcast the nearest emergency exit and the customized route to every handheld terminal based on their locations, thus helps to protect the customers in these situations.

4. Case Experiments Results

In the laboratory, we deployed a wireless location network. The laboratory area is about $112M^2$, and a total of nine positioning nodes are placed in the laboratory. To make wireless access points cover as great range as possible, we put these nodes right below the ceiling height, and reverse the antenna (which can be spread out down the signal) as described in [8] This deployment minimizes not only the signal absorption of the ceiling and the floor, but also the degree of interference. The antenna faces to the ground, and the distance between two nodes is about 5m. In this network, we conducted a network-related test and development. As for location map engine, we use Google Maps API V3 for development. We implemented the customer location, product information display and product navigation in this case experiment. Some user interfaces are shown in Figure 6.

5. Conclusions and Future Work

This paper presents a novel locating technology based shopping management system, which combines wireless location technology with business intelligence. LSSS can let customers conveniently take control of the shopping information and get a personalized shopping experience by interacting with background system. As LSSS has real application potential, we plan to keep researching on some crucial features for the customer experience in a real shopping center to make LSSS more intelligent. For example, we will keep working on shopping route optimization, to let user choose the route from the candidates. Moreover, with the capacity to setup optimized shopping route, we will research on the customer traffic scheduling, trying to figure out how to reasonably model the congested route and assign corresponding importance weight to them, then we can predict the possible congested locations in real time with the up to date customer location information in the whole shopping center, and guide the customers pass around these spots.

Acknowledgements

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