DEVELOPMENT AND IMPLEMENTATION OF AN E-RESTAURANT FOR CUSTOMER-CENTRIC SERVICE USING WLAN AND RFID TECHNOLOGIES

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Abstract:

Traditional restaurants only provide passive service where waiter can only deal with customer's order by asking customer's need and then waits for answer. However, a high quality service system should be customer-centered, i.e., customer's identity and therefore his/her favorite meals and expenditure records in past days can be immediately recognized by service system so as to provide customer-centric services. To achieve this goal, this study integrates RFID and wireless local area network (WLAN) technologies to implement an e-restaurant for customer-centric service, which enables waiters to immediately identify each customer via his/her own RFID-based membership card and then actively provides customized services. The user interface of the proposed system is built with Visual C# 2005 and eMbedded Visual C++, and the database is built on Microsoft SQL Server 2005 for server management and statistic reporting. WLAN and RFID are used to transmit the real-time information of each dining table. Experimental result reveals that the proposed system has potential for practical application.

Keywords:
RFID; wireless local area network (WLAN); e-restaurant for customer-centric service

1. Introduction

In a general restaurant the service process from reservation, making order from the menu, delivery of meal to paying the bill, requires waiter to make notes according to each customer’s order and then transmit them to the kitchen for preparation. When customer pays the bill, the amount due is also calculated by the cashier according to the note. Though such a manner is very simple, it may significantly increase the workload of waiters or even cause mistakes in note-making or inconsistent priorities when the number of customers suddenly increases during dining hours; thus seriously degrading overall service quality. Therefore, how to effectively improve the service quality for customers by using advanced technologies has received much attention in recent years [1-3]. For instance, the counter system of many fast food restaurants in Taiwan is equipped with a touch-screen, keypad or mouse control interface for cashier to address customer’s needs. This kind of system usually has the common Point of Sale (POS) function, which allows waiters to use an optical scanner to directly read the 2D barcode for order details and total charge. However, with this system the waiter can only deals with each order on POS system by asking customer’s need and then waits for answer. Therefore, only passive service can be provided.

However, a high quality service system should be customer-centered, i.e., customer’s identity and therefore his/her favorite meals and expenditure records in past days can be immediately recognized by service system so as to provide customer-centric services. To achieve this goal, this study will integrate RFID and wireless local area network (WLAN) technologies to implement an e-restaurant for customer-centric service, which enables waiters to immediately identify each customer via his/her own RFID-based membership card and then actively provide customized services. Also, customers can use the RFID-based membership card to pay the bill instead of using cash. Moreover, to facilitate waiter’s dining table service, this research develops portable service unit on personal digital assistant (PDA). By means of the PDA-based service unit customer’s order can be instantly transmitted via WLAN to the kitchen for meal preparation. Also, the expenditure information can be sent to the counter for pre-processing of bill. The restaurant managers can access to the database for mastering the business status anytime and making appropriate redeployment for food materials.

It is worthy to note that all the order information and expenditure contents have been digitalized to store in the database; which allows restaurant owners to consider adequate discounts or promoted service to customers based
on expenditure statistics. Customers will thus appreciate high quality service and the image and business revenue of the restaurants can also be significantly enhanced. The rest of this paper is organized as follows. In Section 2, literature review including RFID technology is introduced. An e-restaurant for customer-centric service is presented in Section 3. Section 4 describes the implementation of a wireless ordering system. Finally, conclusions and Future works are given in Section 5.

2. Literature Review

Following the e-Taiwan and M-Taiwan promotion projects, the Executive Yuan of Taiwan Government has launched one new project called “U-Taiwan (Ubiquitous Taiwan)” to boost the IT industry in Taiwan. This project utilizes the latest radio frequency identification (RFID), WLAN, and broadband communication technologies, to build a ubiquitous information environment by exploiting the ubiquitous functions of wireless communication technologies. Such project is expected to launch the “second IT revolution” [4] and create another miracle of technological and economic development.

RFID is an electronic information carrier. It features remote distance reading ability, a high storage capacity, and identification of objects or human beings. In recent years, RFID system has widely been applied to business automation. In [5] an RFID system has been applied in postal logistics management. In [6] a telemedicine application was proposed which developed an RFID-based intelligent position tracking system to locate patients. In [7], an RFID system was applied in campus to provide guidance to the blind people. In their implementation, all the walkways in the campus were embedded with electronic tags, and the tags were connected to the Path Finder application server. The RFID tag on the blind people can reflect the tag number to the current location and the RFID tag reader can actively provide the voice information of the location to guide the blind people. The application of RFID in mobile commerce has been proposed in [8] which installed an RFID tag reader on the mobile device, the mobile device can communicate with RFID tags to increase business efficiency. In this study, RFID system will be applied to develop a customer-centric service system. With the help of WLAN and RFID technologies, order information can be instantly transmitted to kitchen for fast preparation and all expenditure statistics will be automatically stored in database for post-processing; thus achieving high service quality. The RFID technology is introduced as follows.

2.1. RFID technology

The basic framework of RFID is shown in Figure 1. It uses electromagnetic induction to achieve the purpose of automatic identification of tagged objects.

![Figure 1. Basic RFID framework](image)

2.1.1. Advantages of RFID

The advantages of RFID are as follows:

1. Large storage capacity: RFID not only stores codes but also text format information. A general barcode has only 13 digits, but an RFID tag can store about 100 times of 12 bits or \(10^4\) bits.

2. Contactless identification: RFID features a faster scanning speed than traditional barcode system. RFID tag reader is able to identify data in the tag within 250 mini seconds. It can remotely identify an object even out of sight.

3. Identification of multiple RFID tags at one time: RFID tag and reader allow one-to-one, multiple-to-one, one-to-multiple, and multiple-to-multiple identifications.

4. Rewritable tag: Information stored in barcodes can not be modified, but information stored in RFID tags can be updated, added or rewritten. However, there are also RFID tags that do not allow updating or rewriting of information.

5. Long durability: RFID tags have an expected life time of 10 years. They are water-proof, magnetic-proof, heat-endurable, and workable in adverse environmental (weather) conditions.

2.1.2. Disadvantages of RFID

The disadvantages of RFID are as follows:

1. Effective distance: The communication distance between RFID tags and readers ranges from a few mini-meters to several meters, so the distance should be selected according to application purpose. When multiple tags are to be identified, it is necessary to avoid conflicts with other systems.

2. Price: RFID tags are more costly than traditional barcodes. With the cost of RFID readers, encoders, and antennas, the initial investment is considerable.

2.1.3. Types of RFID

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RFID can be classified into active RFID and passive RFID based on power supply methods. Active RFID supplied with battery supports communication link over 10 meters and can actively process and transfer data. RFID tag of passive RFID without battery supply is activated after power is received from the antenna. Thus, its communication distance is shorter than the active RFID, and it is unable to actively process and transfer data. This study will employ passive RFID of electromagnetic coupling type, which operates in the high frequency band (HF, 3~30 MHz).

3. System Structure

3.1. Hardware subsystem

Figure 2 illustrates the hardware subsystem of the proposed system. The server consists of a PC, database server, and an RFID reader, and the client is a PDA equipped with service software. The RFID Reader Card and RFID tags are respectively shown in Figure 3 and Figure 4 [9]. There are two kinds of service model as follows.

1. When a customer carrying an RFID-based membership card enters the restaurant, the server-site RFID reader at the counter will actively identify the customer and obtain the customer data and expenditure records. The waiter at the counter makes orders for the customer and the order is simultaneously shown on the PC screen for confirmation. After confirmed, the order is transmitted to the back-end server in the kitchen via WLAN.

2. When a customer carrying an RFID-based membership card enters the restaurant and directly walks to a table, the waiter can use a hand-held PDA and the RFID Reader to make the customer’s order. The order is shown on the PDA for customer’s confirmation. Later, the order is transmitted to the back-end database in the kitchen via WLAN.

3.2. Software Subsystem

Figure 5 presents the software subsystem of the proposed system. The subsystem comprises two systems, one is wireless meal ordering system and the other is RFID value-added and checkout system. The wireless meal ordering system is developed based on Microsoft SQL Server 2005 and Microsoft Visual C# 2005. The RFID value-added and checkout system is developed with Microsoft eMbedded Visual C++.

3.2.1. Microsoft SQL Server 2005

SQL Server 2005 is a new generation of data management and analysis software system released by Microsoft. It mainly serves corporate data and allows higher expandability, usability, and security of analytic applications. Besides, it also facilitates the establishment, deployment, and management of those applications [10].

3.2.2. Microsoft Visual C# 2005

Microsoft Visual Studio 2005 is a latest software programming system released by Microsoft. It integrates several software development kits, including Microsoft

### 3.2.3. Microsoft eMbedded Visual C++

eMbedded Visual C++ (latest version 4.0) is an application developer provided by Windows CE.NET with many powerful functions. Through eMbedded Visual C++, programmers can develop Windows CE applications in a friendly environment and consult documentation about the software development kit. The debugging program provided in eMbedded Visual C++ allows programmers to use Microsoft ActiveSync® connection or TCP/IP connection to debug the program. It also provides emulators of Handheld PC Professional, Handheld PC, Pocket PC, and Smartphone platforms.

### 3.2.4. Development of Back-end Database

The back-end database stores the data for front-end access. This can save memory of the front-end system, and the data can be managed in a unified manner. The database structure is shown in Figure 6. ADO.NET (Active X Data Object Dot Net) is a library on .NET Framework, allowing .NET developers to access the database [11-15]. The data access procedure includes using SqlConnection to open the database, using SqlCommand to execute SQL commands, and using SqlDataReader to read the query results. The entire procedure is illustrated in Figure 7. ADO.NET consists of two primary parts:

1. **Data provider**
   - Data provider provides access to a data source, such as a SQL Server data provider. Each data source has its own set of provider objects, but they have a common set of utility classes.
2. **Connection**
   - It provides a connection to communicate with the data source and also acts as an abstract factory for command objects.

![Database structure](image)

**Figure 6. Database structure**

![Data access procedure](image)

**Figure 7. Data access procedure**

### 4. Wireless Meal Ordering System

We integrate WLAN and RFID technologies to...
implement a meal ordering system as shown in Figure 8. This system provides active services to customers and allows the use of RFID-based membership card as an electronic wallet. When a customer enters the restaurant, the counter clerk can use the PC to check the latest conditions of each table to see if there is any dining table available. If so, a waiter will be assigned to guide the customer to the table, and the table status will be changed from “available” to “order pending”. After the waiter escorts the customer to the table, the waiter will ask the customer if he/she has membership card. If the customer is a member, he/she will be asked to present his/her RFID-based membership card, and the waiter can use the RFID Reader on PDA to access the RFID tag. Therefore, the customer’s background, expenditure records, personal preference can be retrieved immediately, as shown in Figure 9. Then, the waiter can provide suggestions and applicable offers to the customer. After an order is confirmed, the information will be immediately transmitted to the kitchen. The table status on the counter PC will be changed from “order pending” to “order taken”, and the number and details of the order will be shown on the PC too. When dining is finished the customer can use either cash or a value-added RFID-based membership card to pay the bill, as shown in Figure 10. If a value-added RFID-based membership card is chosen, the RFID value-added and checkout system will be used. This system is built on PDA for convenience, including activation of membership card, value-added, and checkout. Customers can thus enjoy the cash-free convenience.

The membership card stores the amount of e-money. Customer’s background and expenditure records are stored in the back-end database for ease of backup, query, and statistic reporting. Customers can also enter the website of the restaurant and use the ID on the RFID-based membership card to access the back-end database and retrieve related information. Also, either in the counter side or table side waiter can also manually look up customer’s expenditure information, sales ranking of meals, and revenue. After checkout, the table status is immediately changed from “order taken” to “available”, waiting for the next customer. A list of forms available on the counter-side PC is shown in Figure 11. In Figure 12, a list of tables in the database is illustrated. The following briefly describes the content of Figure 12.

1. Product sales check: A basic list of products is provided, according to the ranking of popularity over the past year, past month, today, and from a specified date to the present.

2. Customer search: Operators can use any key term of any data column to search for certain customers. Besides, customers’ past expenditure amounts and preferences can also be retrieved by customer number.

3. Sales performance check: Historic data, including number of customers and income, can be retrieved.
5. Conclusions

This study integrated Visual C# 2005, eMbedded Visual C++, SQL Server 2005, WLAN, and RFID technologies to implement an e-restaurant to support customer-centric service. This system can actively identify customer’s identification to provide customer-centered services. Experimental result reveals that the proposed system has the potential for practical application and can be promoted in restaurants.

Future works are as follows:
1. To cooperate with some restaurants to verify and improve system functions.
2. To develop a mobile phone-based ordering system so that customer can make order anytime and anywhere.
3. To use electronic bulletin board to present the ranking of popular meals and special offers to customers.
4. To construct a real-time updated webpage, showing the status of each dining table and number of waiting customers.
5. To conduct questionnaire to customers to obtain useful suggestions for system improvement.

References