

Development of a Low Cost Portable Vending System for Prepaid Utility Meter

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Abstract

The use of smart card is rapidly increasing to pay different type of utility bills like electricity or gas bill for prepaid electricity meter or prepaid gas meter respectively. It is time consuming for the consumer to recharge smart card from the vending station if it is far away from home. It is costly to increase the number of vending station too. This paper presents a low cost portable vending system for recharging smart card. It is a micro-controller based embedded system interfaced with GPRS modem, slip printer, memory card, smart card, RTC, LCD and keypad. The system is tested for prepaid electricity and gas meters developed by the Institute of Information and Communication Technology of Bangladesh University of Engineering and Technology. Performance of the developed system is very satisfactory.

Keywords

Portable vending system, smart card, GPRS, PHP, MySQL.

1.0 Introduction

Prepaid metering system has been successfully implemented in different countries [1]. Most of the prepaid system uses smart card to recharge the prepaid meter [2-3]. Smart cards are very secure financial or transactional storage device which have small size and portable capabilities. To ensure the proper use of electricity and gas, Bangladesh government has decided to introduce pre-paid electricity and gas meters throughout the country. In the existing systems in Bangladesh, a consumer needs to go to designated vending station which may be located far from his residence to recharge their smart card [4]. In this paper, a low cost portable vending system is proposed which can be used to recharge the consumer's smart card at any vending station. The vending station may be located in a local shop. The smart card contains the account holder ID, meter ID, default recharge amount and other transaction related information. The smart card is entered into the card reader, the micro-controller read the card information and sends it to the server through the GPRS modem and complete the transaction. At the server end, a server side language, PHP (Pre-processor Hypertext) is used to receive that information and check from MySQL database for validity. The rest of the paper is organized as follows. Section 2 describes the proposed system. In Section 3, the system architecture of the mobile vending system and its different components are described. Section 4 describes the system implementation. Test results are discussed Section 5. Finally, Section 6 concludes the paper.

2.0 Proposed System

The overall system is presented in Figure 1. A shop owner who wants to be utility retailer will have to go to the vending station to buy the mobile vending device. He has to open an account and make a deposit to purchase credit. The consumers need to buy a smart card and also open an account from the vending station by giving their personal information and prepaid meter information. To buy credit, consumers will have to go to the shop owner (mobile vending device holder) with money and the smart card. The shop owner will insert the smart card into card reader of the mobile vending device. The device will read the smart card information and will send it to the server using GPRS connection of the modem. Server will authenticate, and if successful shall update the consumer database and deduct the shop owner's credit deposit. The server shall return updated information to the mobile vending device and the device shall recharge consumer's smart card.

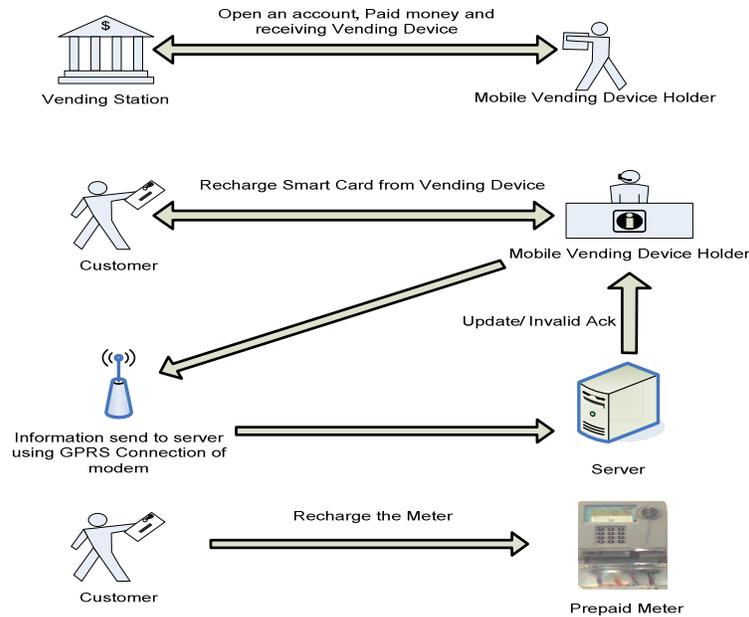


Figure 1: Overall system of mobile vending

3.0 Design of the system

The design of the system mainly consists of two parts: a server for maintaining record of all transactions and actual usage of the user, and a client side vending system that would do actual top-up of the smart card. Figure 2 shows the architecture of the system.

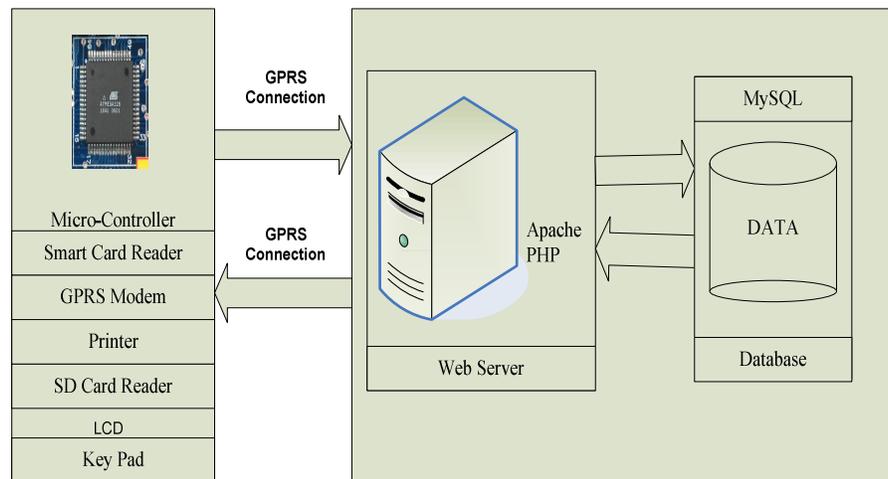


Figure 2: System architecture

3.1 Client Side Vending System

3.1.1 Microcontroller

A low cost 8 bit AVR microcontroller (ATmega128) [5] is used in this system which has 128 kB of program memory, 4 kB EEPROM and 4 kB Internal SRAM. It also has dual programmable serial USARTs and Master/Slave SPI serial interface.

3.1.2 Smart Card Reader

The smart card reader is used to read the smart card and modify user data. In the proposed system, SLE 4428 [6] smart cards are used. The smart card contains necessary data including subscriber ID, meter ID, last vending date and month, etc. The smart card reader is constructed using an interface to connect the smart-card to the board, and the reading algorithm is implemented in the interface.

3.1.3 Hand Held Printer

A hand held printer is used for printing transaction records for the consumer. A pre-assembled handheld printer module from SEIKO Corporation [7] is used for the purpose. The printing module is a thermal printer, and has facility to automatic feed and cut printed paper. The printer is connected with microcontroller through USART serial communication protocol.

3.1.4 Memory Card Reader

A Secure Digital memory card is used so that the encrypted vending data can be stored into it, so that the vending station has record of the transactions that is performed through it. This can be particularly useful in case of a system malfunction or bad write request. A 2 GB SD card from Kingstone [8] is used in the system. In our experiment we store data in raw format, but we still manage option to store data in FAT32 format. The 512 bytes block size is used to read and write data in SD card. So we maintained a buffer structure of 512 bytes of smart card data for information transferring.

3.1.5 GPRS Modem

A GPRS modem is used in the vending device to connect it to internet. This enables the vending system to operate without the need for a wired internet connection.

The GPRS modem is connected with a serial port. USART0 (Universal Synchronous and Asynchronous Receiver Transmitter) of the microcontroller is used for serial communication with the modem. ATmega128 USART units has a transmit pin, a receive pin and an external clock pin. Some AT commands are used to active the GPRS connection of the modem [9].

3.1.6 Real Time Clock

A Maxim real time clock (RTC) is interfaced with the vending device for future use in future. The RTC has 114 bytes of memory. The extra memory is available to store some important offline mode data. The RTC is interfaced with the microcontroller through parallel communication protocol.

3.1.7 LCD

A 16x2 character LCD from Fordata [10] is used as the display unit in the vending device.

3.1.8 Keypad

A 4x4 matrix keypad is used in the vending device for input operation.

3.2 Server Side System

3.2.1 Web Server

Apache [11] has been used as the web server in server side. This web server is platform independent, open source and support server side scripting language to communicate with database.

3.2.2 Server Side Scripting Language

PHP [12], a server side language is used in to get information which comes from the GPRS connection of the modem. This language work closely with the web server to interpret the requests made from the World Wide Web, process these requests, interact with other programs on the server to fulfil the requests, and then indicate to the web server exactly what to serve to the client system.

3.2.3 Relational Database

Relational database management system (RDBMS) provides a great way to store and access complex information. In this system, MySQL [13], open source relational database has been used for this purpose. Figure 3 shows entity relationship diagram of the sample database. There are five entity card_info, vending_info, user_account_info, vending_info and vending_usr_balance_update_info.

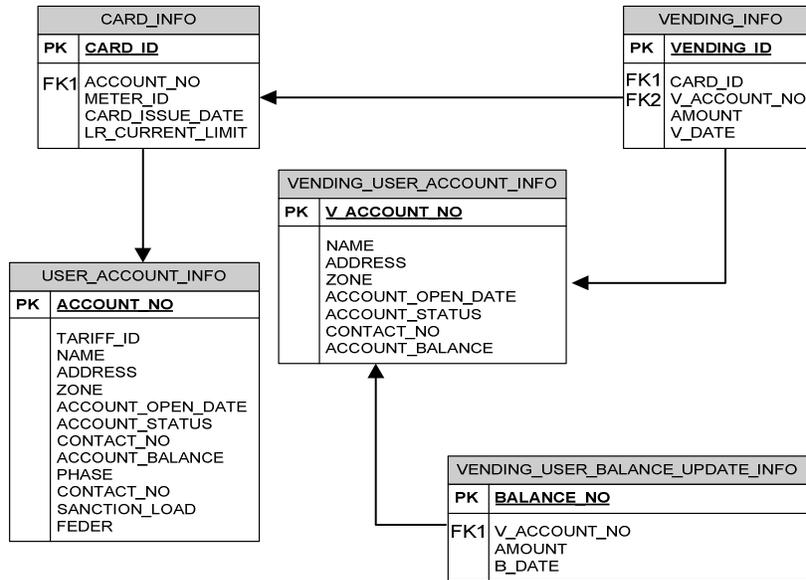


Figure 3: Entity relationship diagram

4.0 Implementation

The mobile vending system works in different sequence as shown in Figure 4. Smart card is inserted into card reader which is embedded with the system. Micro-controller program reads the smart card information and sends it to the server using GPRS connection. Server checks the validity from the database and acknowledgement is sent to the client system. According to validity information, the client system sends the vending amount to the server. Server updates the amount from the database according to the smart card information. After the update is completed, the server sends acknowledgement and the client system writes the new recharge value into the smart card.

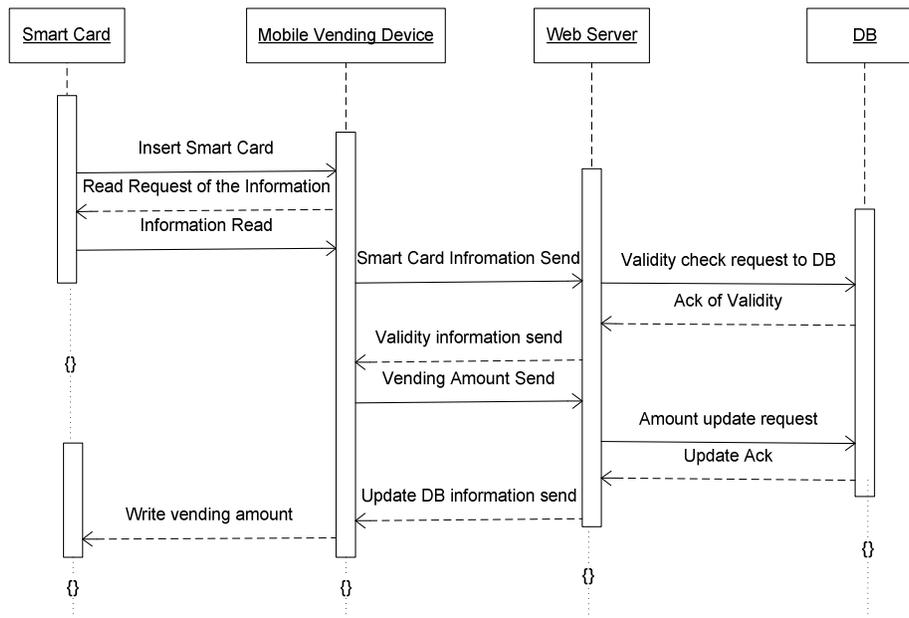


Figure 4: Vending system sequence diagram

When the vending device is powered on, it requires security code to make it operational. Vending device holder enters the security code by keypad. Device checks the security code and if validity is found it will wait for smart card insertion. This validity check is done once while the device is turned on. Now the device is ready to provide service. After a smart card is entered in the vending device, it checks the validity of the card. If card is valid, the device reads consumers information from the card displays consumer ID and consumer name on the display. Then it offers the vendor to start vending. The vending can be set at the default amount that was written on consumer's card previously or change that amount according to consumer's requirement. After selecting the appropriate amount vendor request to server for vending through the GPRS modem. When the server receives a vendor request it performs the following tasks:

- a) It checks the vendor's deposit amount and compare with the amount that is request for vending. The parameter pass through this function are vending station ID, consumer's ID, amount request for vending. Some additional information can also be passed through this function like six month data.
- b) It notes the time.
- c) It checks the monthly charge status and makes decision about monthly charge.
- d) Then the server generates a transaction ID.
- e) The server then completes a buffer set (a complete structure) for the vending station.
- f) Finally it sends the buffer structure to the vending station.

The whole operation takes only a few moments. After a successful reception of buffer structure vending device write vending amount and other information from the structure to the card. It sends a confirmation message to the server after writing successfully in the card. Server take the confirmation message and store it for further reporting. The vending device print a transaction slip through SEIKO slip printer and the vendor provide it to the consumer. This concludes a successful transaction for the pre paid system.

5.0 Testing the Overall System

A portable vending system prototype (shown in Figure 6) is developed and several tests have been conducted. We developed three mobile vending devices and one central server. The total time taken to get data from the vending device to the central server is approximately 35 seconds using GPRS connection of the modem. This time may vary a little bit depending upon the GSM network condition. In our tests, for 97% cases, data was received successfully by one attempt. The remaining 3% cases, data were received after second or third attempt.

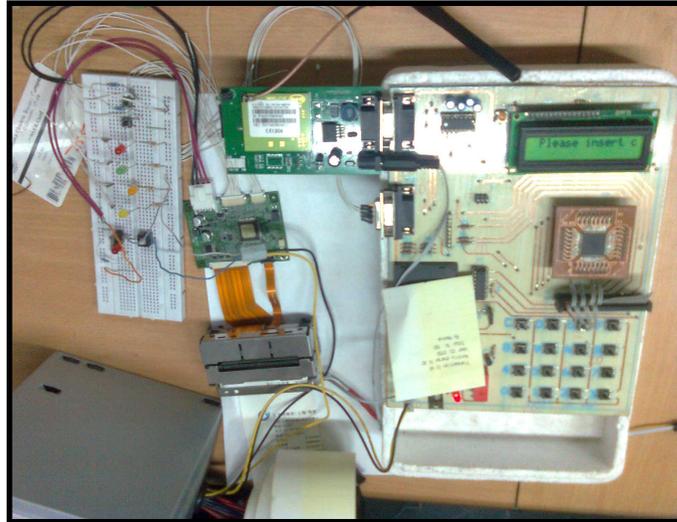


Figure 5: Laboratory prototype of the vending device

We have tested the system performance at different worst case scenarios like modem SIM without any credit balance, invalid account ID, invalid amount insertion and invalid smart card insertion. The system gives proper error messages on the LCD. The correct information inserted and updated into the server side database has been tested and verified by display on the LCD and printing document. The SD card and RTC are successfully interfaced for further use of the system.

The mobile top-up system used in Bangladesh uses short message service (SMS) to transfer information between the server and the retailer. It does not use internet. The retailing device is a mobile. Hence in Bangladesh, no similar vending system as proposed by the authors exists at this moment.

6.0 Conclusions

In this paper, a low cost, portable and secure mobile vending system was proposed and its design components have been discussed. A prototype of the system has been successfully implemented and tested. The proposed system has the benefit for the consumer to recharge their smart card from easily reachable distance. Utilities need not establish different vending stations in different zones. Shop owners are also benefited from the proposed system. The proposed system features the using of GPRS modem, which provides remote access to the server without the additional cost of a personal computer.

Acknowledgment

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