TELKOMNIKA, Vol.14, No.3, September 2016, pp. 839~845
ISSN: 1693-6930, accredited A by DIKTI, Decree No: 58/DIKTI/Kep/2013
DOI: 10.12928/TELKOMNIKA.v14i3.3114

Arduino Based Paperless Queue Management System

Aiman Zakwan Jidin*[1,3], Norfadzlia Mohd Yusof[1], Tole Sutikno[2]
[1]Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka
[2]Department of Electrical Engineering, Universiti Ahmad Dahlan
[3]Center for Telecommunication Research and Innovation, Universiti Teknikal Malaysia Melaka
*Corresponding author, e-mail: aimanzakwan@utem.edu.my

Abstract

Queue management system is designed in organizing queues at service sectors like banks and post offices, which expected to have a large number of customers daily. Conventional ways of managing queues like issuing paper tickets printed with queue number lead to several problems such as paper tickets littering and also long queueing or waiting time. Therefore, this paper presents the development of a system to manage queues more efficiently and eco-friendly. The proposed system consists of a Graphical User Interface (GUI), which is used to obtain customers' mobile phone numbers and the processing unit, which generates the queue number and initiate the ticket to be sent to customers' mobile phones via SMS, thus replacing the utilization of papers. Moreover, this system additional features allow customers to remotely obtain their queue number just by sending a request to the system through SMS and also reminding the upcoming customers that their turns are nearly arriving, a feature which is very useful especially for those who are waiting outside the premise. Simulations and experimental tests were conducted to ensure the reliability and the efficiency of the proposed system. The proposed system is supporting the development of sustainable green technology, and the expected increase of system efficiency may contribute to improving customers' satisfaction.

Keywords*: queue management, green technology, SMS, arduino, processing language*

1. Introduction

Queueing system in a customer service office can be described as a system where the arrivals of a new customer are the input, and served customers are the outputs. In this system, customers have to wait for their turns to be served since usually the numbers of servers are outnumbered by the number of waiting customers [1]. Customer queues always exist in service sector offices, such as banks [2], clinics and pharmacies [3], and ticket sales offices [4].

Thus, managing queues in such premises became a prominent issue, since these premises always tend to get very crowded, especially during peak periods. As the customer satisfaction is one of the causes for concern in the service sector, an effective way of managing queues is essential, since long waiting time and lack of information from the service provider may lead to customer dissatisfaction [5-6]. Moreover, their observation on the queue length and the number of people waiting in the premises may also influence their satisfaction. As the consequences, problems in managing big crowds and long waiting queues will lead to low service rate of the service providers, poor business environment and also a potential loss of customers [5].

The queues may be formed in different ways at different places. For example, people may queue up in a line in order to buy tickets at the ticket counters, whereas offices like banks and post offices will issue the turn numbers to their customers, which are printed on pieces of paper. The latter may contribute to another issue, where the papers are heavily used in order to issue tickets to the customers.

There are many alternatives which had been proposed in order to manage queues in the service sectors more efficiently. Several papers had conducted queueing model analysis by using computer simulations and queueing theories, in order to optimize the queueing time during both peak and off-peak periods and thus increasing the efficiency and quality service. Their analysis produced various outcomes, such as the customer expected waiting times [4], the optimized number of the counters [7], and also the adequate number of manpower to serve customers [8]. Besides, with the rapid advancement of ICT, e-services have become popular

Received April 18, 2016; Revised June 13, 2016; Accepted June 30, 2016

alternatives to many service agencies, where the number of customers at the premises can be reduced since the services can be delivered electronically online [9]. However, not all type or nature of services are entitled to the e-services, as customers still need to come to the offices in order to renew their identification cards or passports, for example.

This paper presents an effective way of managing queue at customer service offices via the development of Arduino Uno based paperless queue management system, which consists of a processing unit which is connected to a graphical user interface on a Windows-based PC. Furthermore, the processing unit is also tied to a GSM module and thus, the paper tickets can be replaced by SMS tickets which are sent to customers' mobile phones, thus reducing the usage of papers. Besides, additional features such as reminder SMS and remote ticket request will reduce the waiting queue length and the number of people in the premises. The functionality of the proposed system is observed in the results and discussion section.

Arduino is an open source and user-friendly platform for hardware and software prototyping. The Arduino boards contain a microcontroller, which is controlled by using Arduino programming language, which is based on C++ programming language. There is a variety of Arduino device families available, such as Arduino Uno, Arduino Mega, Arduino Due, and Lilypad Arduino [10]. Owing to their simplicity, low development cost, and multiplatform support, Arduino boards are now widely used in various applications, such as digital sound processing [11], automated control systems [12], motor drives [13-14], and also as learning tools [15-16].

2. Research Method

In this section, the architecture of the proposed system and its operational flow are described. Then, the method used in developing the system is explained.

2.1. Proposed System Architecture

Figure 1 illustrates the architecture of the proposed queue management system, in the form of a diagram. As can be seen from this picture, the system consists of a GUI-based desktop application on a computer that is serially and bidirectionally communicates with Arduino Uno board, which acts as the processing unit and core for this system. The processing unit interfaces with SIM900A GSM/GPRS module for receiving and transmitting SMS. In this research, the push button connects to the processing unit to serves as the button at the counter to call upon the next customer in the queue.

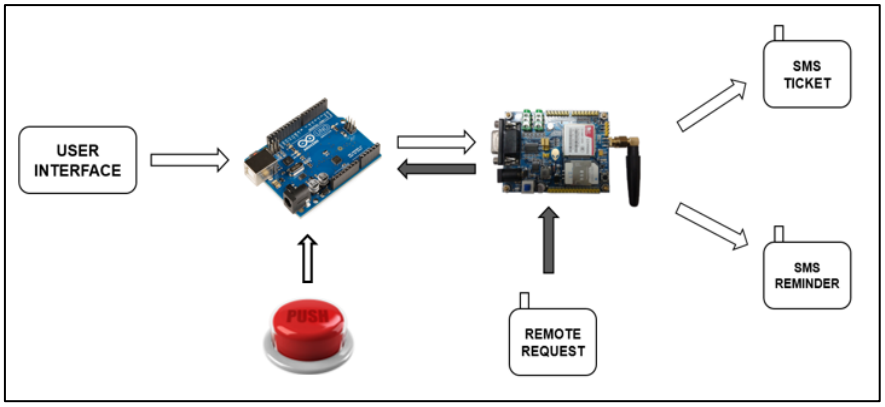

Figure 1. Architecture of Queue Management System

Figure 2 illustrates the system operation flow once a new customer enters his or her phone number using the provided GUI. After the mobile phone number is entered, the mobile phone number and other related data will be sent to Arduino UNO board for processing. The output from the processing unit is the SMS ticket containing queue information such as the queue number, the current queue number at the counter and the number of remaining customers, similarly to the printed paper ticket used in the conventional method. The SMS ticket

is then sent via SMS to customer's mobile phone using the phone number that has been entered earlier.

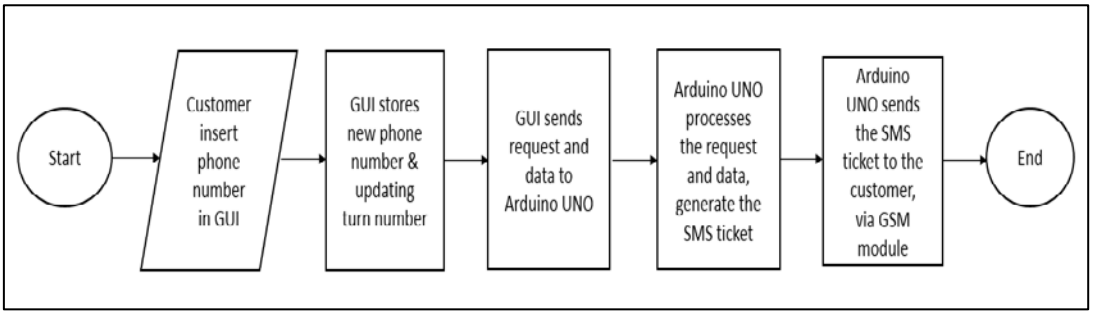

Figure 2. The System Operational Flow Chart for Requesting SMS Ticket Using GUI

On the other hand, the proposed system also allows new customers to remotely check the queueing status at the premise and also request for a new SMS ticket, without physically being there. By simply using their mobile phones, customers can make a remote request by sending a specific instruction via SMS to the system. The SMS will be received by the GSM Module and then processed by Arduino UNO to generate the SMS ticket. The generated SMS ticket is then issued to the customer via SMS. Next, Arduino UNO will also prompt the desktop application in order to update the new queue number being issued and to store the new phone number in the system, thus synchronizing the remote access tickets with the regular access tickets at the premises. This process is illustrated in Figure 3. This feature is eligible to all customers, without any pre-registration of their mobile phone numbers in the system.

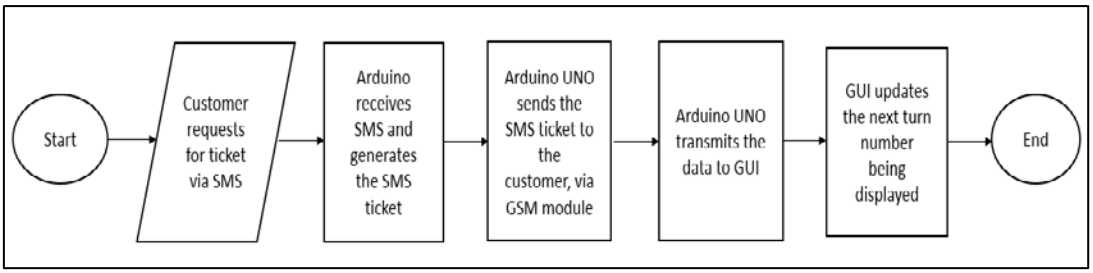

Figure 3. The System Operational Flow Chart for Requesting SMS Ticket Remotely Via SMS

This system also provides SMS reminder functionality, as depicted in Figure 4. SMS reminder operates each time when a customer is served at the counter. When a customer is being called to the counter, the system in the computer will determine whether the reminder is necessary for the upcoming customer. In that case, it will generate a request to Arduino UNO to generate reminder SMS and transmit it to the nearly upcoming customers. For this research purpose, a push button is connected to the Arduino Uno board, as can be seen in Figure 1. Once the push button is pressed, the next customer in the queue is called to the counter and in consequence, the new queue number being served at the counter displayed at the GUI is updated.

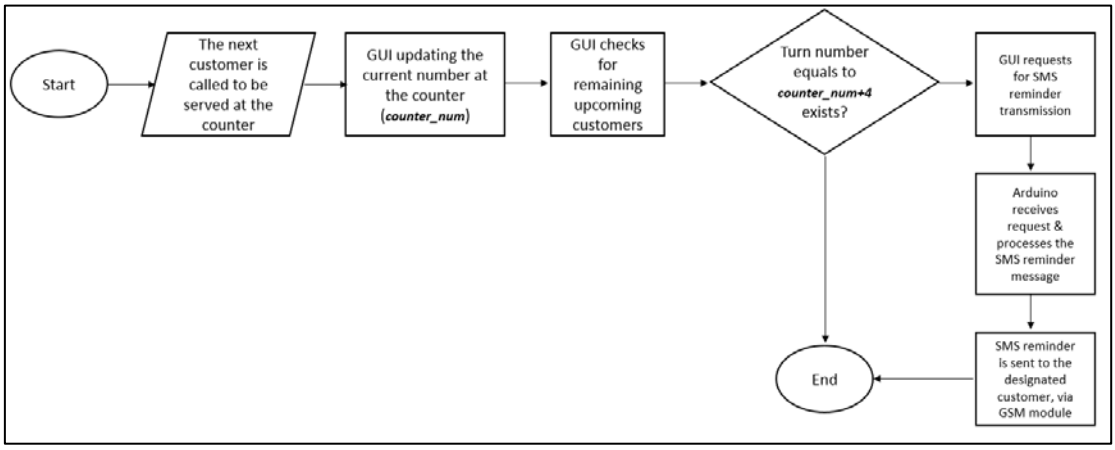

Figure 4. The Flow Chart of SMS Reminder Generation and Transmission

2.2. System Development

2.2.1. GUI-Based Desktop Application

The desktop application has been developed by using the Processing Software, which is a language widely used within the context of the visual art [17]. This desktop application provides a GUI that contains a text box which is used to enter a newly-arrived customer's mobile phone number. Besides, the GUI also displays the queue information status: the queue number currently being served at the counter and the new queue number that waits to be issued to the next incoming customer.

2.2.2. Processing Unit

The processing unit of the system is represented by the Arduino UNO board. It is the core of the system which controls most of its operations, such as processing the ticket request from the user interface, creating the SMS texts, and also generating the SMS transmission. All the operations managed by the processing unit are coded by using Arduino programming language. Besides the setup() and loop() functions, it contains other essential functions, as below:

1. readSerial() function, to received information sent by the user interface.
2. serial.println() function, to send information to the user interface.
3. send_first_sms() function, to generate and then transmit the SMS ticket to designated customers.
4. send_reminder_sms() function, which generates and then send the SMS reminder to selected customers.
5. send_eticket_sms() function, which receives and processes the SMS tickets for remote request cases.

The SMS reception and transmission is managed by using the GSM.h Arduino library. SMS texts can be easily initiated and read, by using the sms.print() and sms.read() functions provided in the library. Thus, short development time is required and ease of coding without the need of developing the AT commands, which are quite complex.

2.2.3. Queue Number Generation

This system will generate the new turn number or the queue number on two occasions: when a new customer enters their phone number through the GUI-based desktop application or when the system receives a remote ticket request via SMS. For this research purpose, this number shall contain four digits. Therefore, the current system limitation on the maximum number that can be generated per day is 10000 tickets, since the range of the sequence is from 0000 to 9999.

Each time a new queue number is generated, the GUI will send the updated queue information to the Arduino, in order to generate a new SMS ticket to be sent to desired recipients.

3. Results and Discussions

Functionality testing has been carried out to verify that the system functions correctly according to the design specification. Several test cases have been created and the results from the tests are observed and analyzed.

3.1. Tests

Figure 5 shows the hardware setup in order to performed tests. The GSM Module is serially connected to the Arduino UNO board, where the TX port of the GSM Module is connected to the RX port (PIN 2) of the Arduino UNO, while RX port of the former is tied to the TX port (PIN 3) of the latter. The Arduino UNO board itself is connected to the user interface in the PC via USB port. Furthermore, a push button is connected as the input for the Arduino UNO, via PIN 7.

Several test cases were created first before performing the tests and thus, all the possible scenario will be covered and verified. The following are the all the steps which need to be verified:

a) Launching the User Interface application
b) SMS Ticket transmission to new customers
c) SMS Reminder transmission to upcoming customers to be served at the counter
d) Processing remote request for SMS Ticket

3.2. Results

Figure 6 shows the GUI of the system, after being launched on the computer. In the GUI, customers should see a textbox for entering the mobile phone number and also the queue information such as the queue number currently being served at the counter and the next queue number to be issued. In this GUI new customers need to enter their mobile phone numbers and pressed Enter. The Reset button at the bottom left of the GUI is used to clear the textbox.

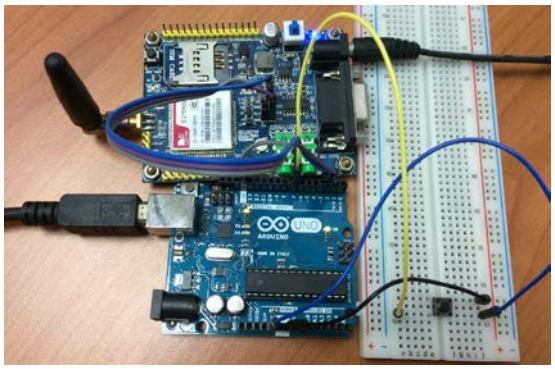

Figure 5. Hardware Setup for Tests

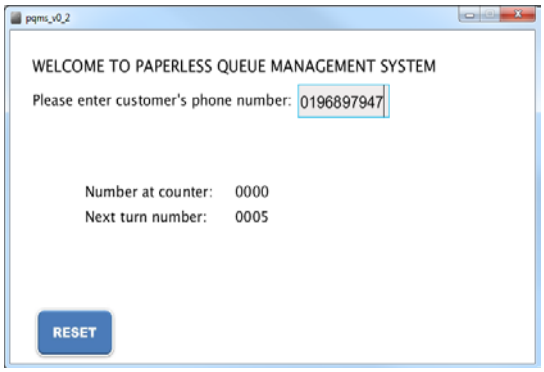

Figure 6. Demonstration where a new customer is entering the mobile phone number in the GUI

In Figure 6, the GUI displayed “Number at counter: 0000”, which tells that currently there is no customer is being served at the counter. “Next turn number: 0005” is the next queue number that will be issued to the new customer. The demonstration shows that a new customer has entered a mobile phone number 0196897947. Once the mobile phone number is entered, that customer receives an SMS Ticket containing all necessary information, as illustrated in Figure 7. According to the SMS ticket, this particular customer obtains 0005 as his queue number.

While waiting for his turn, the same customer may tend to go outside doing other things. In the case where the first customer with queue number 0001 is being called to the counter, the system detects that the queue number 0005 exists in the system. Therefore, it will send an SMS to that customer as can be seen in Figure 7, in order to remind that particular customer to be prepared, since his turn to be served is about to come.

Figure 8 shows how a customer can remotely request for a ticket remotely by using SMS. This customer makes a request by simply sending a command “QMS TICKET”, and receives an SMS ticket on his mobile phone shortly afterward.

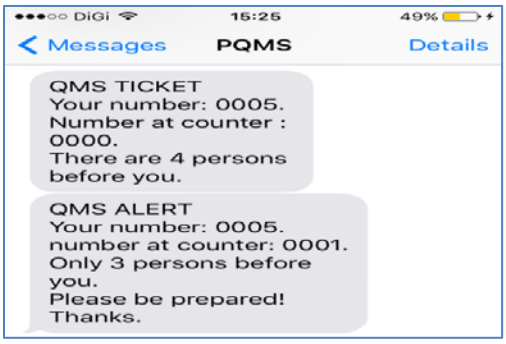

Figure 7. SMS Ticket and SMS Reminder Sample

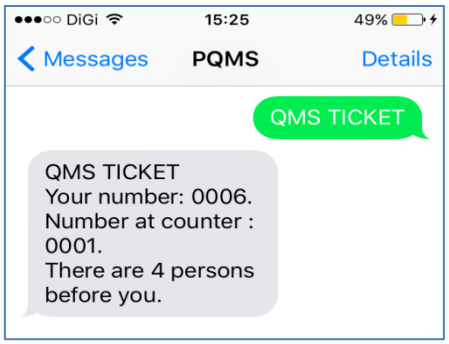

Figure 8. Remote Request for Ticket

3.3. Discussions

Since it uses SMS in order to replace the conventional paper ticket, this system may allow the reduction in terms of paper utilization. Moreover, there is no concern about the coverage range, since there is no range limitation for GSM, unlike other wireless alternatives such as Bluetooth or WiFi. Thus, the tickets can be sent to the customers’ mobile phone even if they are far away from the premise.

However, the performance of the system may depend on the coverage of the network operator. A very good signal strength will allow very fast response, so customers may obtain their SMS ticket in very short times. In the worst case where the network coverage is very weak, the SMS may take very long time to be transmitted, and therefore, an alternative must be provided.

3.4. Recommendations

There are rooms for improvement which can be done on the proposed system. For example, it should be deployed in the database server to increase system efficiency to support a large number of users. A storage such as a database should be used to store data. This will be very useful in the case of the power outage at the premises and thus, all data will not be lost after the system reboot.

Several other features can be added to the existing system in order to improve the reliability and the effectiveness of the system. As mentioned in the discussions section, customers can have the option to print a paper ticket, just like in the conventional method, in such case or in the case where they don’t have a mobile phone. Besides, the system shall be developed as a web application so that it can be accessible anytime and everywhere.

4. Conclusion

This paper has described the implementation of paperless queue management system on an Arduino UNO board. The proposed system, which replaced the conventional paper ticket with SMS ticket, may reduce the paper usage at customer service premises. Furthermore, it also provides additional features such as SMS Reminder generation and ability to process remote ticket requests via SMS, which allows more efficient queue management. The test results show that all functionalities in the system have performed correctly, where all the possible cases are verified. However, there are rooms for improvement, to make the system more useful, more reliable and effective. It may contribute to making the green technology and maximizing the customers’ satisfaction.

Acknowledgements

The authors wish to acknowledge the Centre for Research and Management (CRIM) of Universiti Teknikal Malaysia Melaka (UTeM) for the financial funding and providing instrumentation devices support of this project.

References

[1] Delgado CA, van Ackere A, Larsen ER. *A queuing system with risk-averse customers: sensitivity analysis of performance.* IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). Singapore. 2011: 1720-1724.
[2] Xiaobing P. *An application of OR and IE technology in bank service system improvement*. IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). Singapore. 2008: 638-642.
[3] Alhaag MH, Aziz T, Alharkan IM. *A queuing model for health care pharmacy using software Arena*. International Conference on Industrial Engineering and Operations Management (IEOM). Dubai. 2015: 1-11.
[4] Huang Y, Yao F, Ji S. *Queuing theory based simulation and optimization of ticket office*. IEEE Workshop on Advanced Research and Technology in Industry Applications (WARTIA). 2014: 1217-1219.
[5] Xiao H, Zhang G. *The queuing theory application in bank service optimization*. 2010 International Conference on Logistics Systems and Intelligent Management. Harbin. 2010; 2: 1097-1100.
[6] Zhao XX. Queueing theory with the bank management innovation. *Modern finance.* 2007; 3: 9-10.
[7] Ullah A, Zhang XD, Iqbal K, Ayat M. *Sub-optimization of bank queuing system by qualitative and quantitative analysis*. 11th International Conference on Service Systems and Service Management (ICSSSM). Beijing. 2014: 1-6.
[8] Liao GL, Chiang WH. *Optimal scheduling problem for Taiwan's post office counters and manpower*. IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). Bangkok. 2013: 111-115.
[9] Mohammadi S, Yaghoubi P. *Analysis of revealed comparative advantage in the e-service market*. IEEE International Conference on System of Systems Engineering (SoSE'08). Singapore. 2008: 1-6.
[10] http://www.arduino.cc/
[11] Silva S, Soares S, Valente A, Marcelino ST. *Digital sound processing using arduino and MATLAB*. Science and Information Conference (SAI). London. 2015: 1184-1191.
[12] Teslyuk T, Denysyuk P, Kernytskyy A, Teslyuk V. *Automated control system for arduino and android based intelligent greenhouse*. XI International Conference on Perspective Technologies and Methods in MEMS Design (MEMSTECH). Lviv. 2015: 7-10.
[13] Zulkifli SA, Hussin MN, Saad AS. *MATLAB-Arduino as a low cost microcontroller for 3 phase inverter*. 2014 IEEE Student Conference on Research and Development (SCOReD). Batu Ferringhi. 2014: 1-5.
[14] Jayetileke HR, de Mei WR, Ratnayake HUW. *Real-time fuzzy logic speed tracking controller for a DC motor using Arduino Due*. 7th International Conference on Information and Automation for Sustainability (ICIAfS). Colombo. 2014: 1-6.
[15] Galadima AA. *Arduino as a learning tool*. 11th International Conference on Electronics, Computer and Computation (ICECCO). Abuja. 2014: 1-4.
[16] Esposito WJ, Mujica FA, Garcia DG, Kovacs GT. *The Lab-In-A-Box project: An Arduino compatible signals and electronics teaching system.* IEEE Signal Processing and Signal Processing Education Workshop (SP/SPE). Salt Lake City. 2015: 301-306.
[17] Casey Reas and Ben Fry. Make: Getting Started with Processing, Second Edition. Maker Media. 2015.