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Queue Monitoring System for Bank

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Abstract
Automated queue system research has received much more attention due to increase customers in public and private places. The queue monitoring system helps banks in providing customers with efficient services. In this paper, a queuing problem in bank premises, especially in Nigeria, is being considered. Due to that, we propose a queue monitoring system using Internet-of-Things (IoT). This system uses two infrared (IR) sensors, one at the entry and the other at the exit. The IR sensor at the entrance counts the number of customers to be served while the other IR sensor counts the number of customers that have been served. The system displays the number of customers waiting on the queue for both the customers and bank staff in real-time. The evaluation results indicated that the system accuracy rate of the sensor technology was 80% for customers counting and 90% real-time data representation on the web application.

Keywords: Queue, Infrared sensor, Automatic teller machine(ATM), Wi-Fi microcontroller

INTRODUCTION
The core aim of every financial institution is not to lose a customer by providing the customer with services that will satisfy their needs. Customers experience poor service delivery, especially when it entails waiting in long queues. Poor management of these scenarios in banks could result in many customers leaving without either depositing, withdrawing, or both in Nigeria. These could as well depreciate the output of the banking institutions based on poor service delivery experienced, whereby customers would not be interested in seeking or using such bank institutions. The challenges of the long queue are experienced in Automatic Teller Machines (ATMS) and the banking hall (Gabriel, 2011)

For this reason, some citizens of the country prefer to keep their money at home, although Automatic Teller Machines (ATMs) are available. On few occasions, these machines tend to

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be out of cash or service. The primary cause of this problem is slow infrastructure growth and a large number of citizens in the country (Gabriel, 2011). Therefore, we introduce an automatic queue monitoring system that will help resolve the issue inside the banking premises and not at Automatic Teller Machines (ATMs).

The requirement pushing toward the design of a queue monitoring system is to provide quick services to customers. To achieve that purpose, an Internet of Things (IoT) system can be built using an infrared sensor module and ESP 8226 (node MCU). This reduces installation cost significantly, giving customers an insight into the queue situation, as well as real-time analysis on when to increase service (human resources) or service (speed) in the financial institution. Thus, making deployment in large-scale feasible.

Researches on queue monitoring were more on the vehicles, which led to the implementation of a vehicle monitoring system. The system is an intelligent transportation system or intelligent traffic signal (Yang et al., 2013;Cai et al., 2010). The system detects the vehicle queue length when the traffic light turns red (Cai et al., 2010), while the camera installed is to detect the vehicle in real-time. In (BlipTrack, 2015) BlipTrack uses WiFi sensors and Bluetooth to measure speed, providing driving times, and queue warning, which can display variable message signs and mobile applications.

There are ample number of queue monitoring systems for vehicles being developed. Recently, human being queue systems are in development, which is more byzantine. There are some commercial products available that handle the queue of people, but these products do not display the number of customers in the queue for other customers to see. Some of these products are Axis (Identiv, n.d., Lavi, n.d.,) and video turnstiles (videoturnstile, n.d.). The overhead camera is used in most of the products by processing the images on a PC. The products can count the number of customers to estimate the waiting time, and some systems can alert the staff if the queue is long via prompt message, text, or video message.
The Internet of Things (IoT) is a global, huge, distributed network of interlinked independent devices armed with embedded sensors, processors, and actuators enabling them to connect to the internet, exchange data, interact, and communicate seamlessly with one another in real-time. IoT can be referred to as the general idea of things, specifically everyday objects that are recognizable, readable, locatable, addressable through information sensing device and manageable via the internet, regardless of the interaction means (via wireless LAN/RFID / wide area networks /other means) (Friess& Varmesan, 2015)

In this paper, the proposed design of the queue monitoring system is on a very low-cost device in real-time processing. It can count the number of customers who enter and exit the queue; displays it on the web application over the Internet for customers and Bank management analysis to make decisions on service request or provision. The proposed system design will operate on the IoT platform using infrared sensor modules and an Esp8266 Wi-Fi microcontroller.

RESEARCH AIM and OBJECTIVES

This study aims to help bank management manage the queuing system with regards to the welfare and satisfaction of the customers who utilize the services rendered by the bank. This will be achieved by the development of the Internet of Things (IoT) System, which integrates

infrared sensors technologies to detect, monitor, and count the number of customers entering or exiting.

- To investigate the use of infrared in the banking system(through research journals, working prototype)by studying how data from the IOT system operate in real-time
- To study how the IoT system sends data to web applications in real-time
- To design a prototype that will notify the customers on the number of customers in the queue and the bank management for when there is a need to reduce traffic or simply for periodical study.

REVIEW OF RELATED WORK

Viriyavisuthisak *et al.* (2017) developed an automatic queue length monitoring system, the system detects the number of people on queue and if the length of the queue is critical it notifies the staff via Line notification. However, it doesn't display the number of people on queue and the system only notify the staff so no customer will know he number of people on the queue without physically being in the store

Uddin *et al*. (2016) developed an automated queue management system, the system analyses the status of the queue and decides the customer to serve first. The developed system can determine the average waiting time by using two different queue control systems. However, the system is not developed in a way that it will notify either the staff/client the number of customers on the queue.

Ngorsed& Suesaowaluk (2016) proposed a hospital service queue management system with wireless approach, the proposed system nullifies physical queue but manage people queue status using handheld devices via web application. The system requires internet or intranet to work efficiently, although the proposed system will reduce waiting time and patient(s) and stakeholders can do other work, however, in the absence of internet and intranet the system will not be able to function at all

Q-net (n.d) developed a queue monitoring system that uses ticket dispenser with card reader, where the client is given the opportunity to key in their phone number and a message with be sent to them displaying the waiting time and receive alert when their turn comes up. However, the system doesn't display the number of clients on the queue, the system requires ticket which you can only get manually.

Lord *et al.* (2019)developed queue for patient monitoring, where the system is used in an area such as waiting room in the hospital, using vital sign acquisition camera to check the vital signs of each patient and prioritizes more critical condition patients and ensuring all patients are periodically monitored in other to avoid patients to deteriorate. The system is not based on First Come First Serve (FIFO) algorithm. The system can only be used in hospitals to monitor vital signs.

Queuing Management System

A queue management system, control queues of people either structured or unstructured queues. This type of system comprises one or more servers that provide service to customers on arrival. There are two types of customers waiting for line size, which can be finite (limited size) or infinite (unlimited size). The customer randomly arrives at the service centre. The queue symbolises the number of customers waiting to be served, which can be limited or unlimited. The financial institute is an example of an infinite queue while parking

space is an example of a finite queue (Ahmed et al., 2011).

Services are activities requested by customer(s), where each service takes a specific time. Scheduling algorithm specifies the next customer to choose from the queue, the most common scheduling algorithms are as follows:
First Come First Serve (FCFS): This algorithm serves customers in order of arrival, where a customer goes to the end of the queue when the service is busy. It is the most visibly fair service provision as all customers are equal (Uddin et al., 2016; Ngorsed and Suesaowaluk 2016).

Random Selection for Service (RSS): This algorithm serves customers in the queue at random, where each customer in the queue has equal probability of being selected for service. This algorithm does not put into account the arrival time of customer, which means last customer that arrives in the service system can be served next (Willig 1999; Ahmed et al., 2011).

Priority Service (PS): This algorithm serves customers based on priority, the customer with the highest priority is served first (Uddin et al., 2016; Ngorsed & Suesaowaluk (2016)).
Shortest Processed First (SPF): this algorithm chooses a customer in the queue with lesser time to serve first. It is assumed that the algorithm has the knowledge of the service times in advance (Uddin et al., 2016; Willig, 1999)

Equation for the System
Equation for the proposed queuing system to be used, equation 1 is used to calculate the waiting time for each customer (Wiling, 1999).
WT * NC = SST *NC - AT *NC

Where:
WT = Waiting Time for a Customer.
SST = Start Serving Time for a Customer
AT = Arrival time for a Customer
NC = Number of Customer

And equation 2 used to calculate the average waiting time for each group of customers
AWT = $(\sum WT * NC)/\text{TN}$
Where:
AWT = Average Waiting Time
WT = Waiting Time for a Customer
TN = Total Number of Customers Served
NC = Number of a Customer

SYSTEM DESCRIPTION
The queue monitoring system can be described to its properties and behavior of the system. The queue monitoring system is an Internet of Things (IoT) technology, whose aim is to reduce the congestion of customers and improve service delivery efficiency in banks. The queue monitoring system records the number of customers in the queue based on service delivery. This will be a tool to help both service provider (bank management) and customers study the flow of the queue. The queue analysis is paramount in the achievement of efficient service delivery time. Whereby bank

management can ascertain when necessary to increase service providers(cashiers), likewise, the customers can decide at what time will be convenient to request service from the bank to utilize limited time schedules.
The adoption of this queue monitoring system uses the detection of movements across these sensors to count the number of customers that either makes entry or exit from the queue. The system either increments or decrements the number of customers on the queue. Whereby captured sensor readings from the IoT prototype are stored in the database. Thereafter, data from the database are processed, analyzed and represented on a web application in real-time. The detection of entry or exit by a customer either increments or decrements based on the previously stored count data in the database.

SYSTEM DEVELOPMENT AND COMPONENTS

This system consists of infrared sensor modules and an Esp8226 WIFI microcontroller, with a power supply source of either a battery or direct current as represented in Figure 1. The ESP8226 micro controller (Node MCU), is made up of a set of GPIO (General purpose Input/output pins), in which external sensors are connected to it. The Node MCU component is built with a WIFI communications feature that allows the sensor devices connect to the Internet, WIFI network, and can be used as web host server, with the assistance of the Libraries as installed on the Arduino IDE.

The Infrared Sensor Module is a sensor component made up an IR(Infrared) transmitter and receiver. Its basic principle of operation is based an output LED glows when an object is detected within the range of the IR receiver and vice versa.

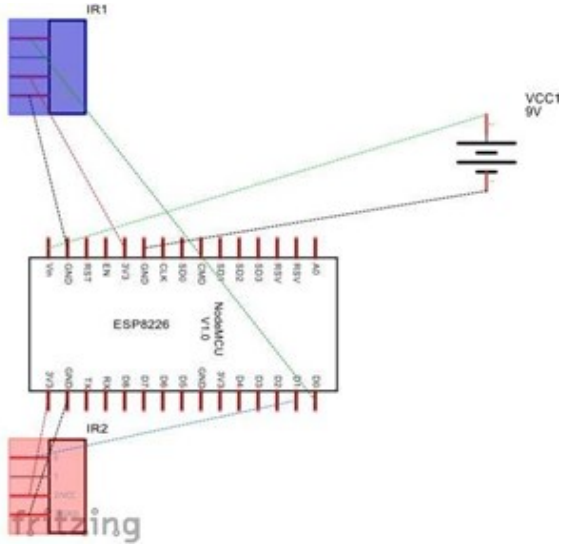

Figure 1 Schematic Design

EXPERIMENTAL RESULT

The developed bank Queue monitoring system was accomplished by the implementation of an Infrared (IR) Sensor Module circuit. Theses circuit was built with two IR (Entry and Exit), on a Wi-Fi (ESP8266-12E) microcontroller. This circuit can be either powered via a 9volts battery or a direct current (DC).

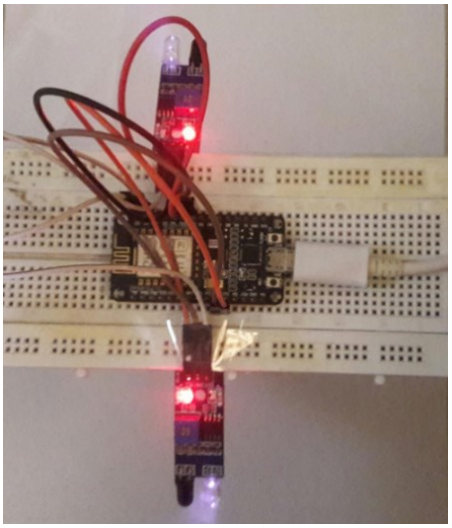

Figure 2: Final Prototype

The hardware system was made functional by use of C programming language on an Arduino (1.8.10) IDE, using latest versions of ESP8266WiFi, Wi-Fi-Client and ThingSpeak libraries. The bank queue monitoring system sends its queue counter of persons currently awaiting service from the bank to web application in a real time over the Internet. The infrared sensors entry and exit increment or decrements its counts by detection of movement across it. The infrared sensor module used to implement this system only detects movement within 1-3cm, thereby it is of extreme important to implement detection sensor or thermal camera technologies of higher distance value. The web application correspondingly represents the data logged into its server in a graphical format, to enable analytical study of the queueing system in respect to number of customers and time. The final prototype and web application are shown in Figure2 and Figure 3.

Figure 3: Web Application1

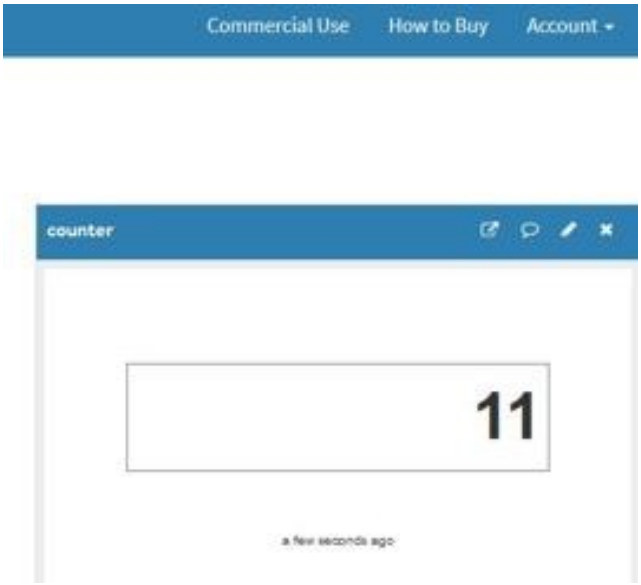

Figure 4: Web Application2

SYSTEM EVALUATION

The process evaluation technique was employed in the developed queue monitoring system. The justification for the use of process evaluation was to establish the operational mode of the developed prototype and to satisfy the goals of this study, which is effective service delivery for customers in a queue. In this research process, evaluation measurement was observed by the effectiveness of the integration to inputs and outputs to the main goal of this project to report accurate queue status in real-time.

Observation of Developed System: This evaluates the activities recorded based on inputs and output during the operation of the developed system. This was performed by a sample space of 10.In order to confirm the performance of the input sensor retrieved from the infrared sensor were transmitted in real time on the system. The program logic of reporting correct number of persons on the queue was correct. The summarized report from returned questionnaires shows that the prototype response to inputs was at 80%, whereas transmission of data to web application was at 90%.

CONCLUSION

This paper addressed the issue of how bank customers can remotely monitor customers in a queue waiting to be served using the proposed queue monitoring system for banks on an IoT platform. We operated the prototype system in Figure2 on Arduino with two infrared (IR) sensors. The IR sensors reading is sent to the database and then displayed on the web application Figure 3 and Figure 4 in real-time. The evaluation results indicated that the system accuracy rate of the sensor technology was 80% for customers counting and 90% real-time data representation on the web application. Although if a customer decides to use the same point of entry or exit as his/her exit or entry, the system won't be able to detect the customer using the same position for entry and exit. This will make the system display a wrong value of the queue. Future work will be using a motion sensor camera to be incorporated the system, as well as the development of a machine learning model for a queue system to achieve effective service delivery to a customer in the queue.

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