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Food Ordering System using IoT Enabled RFID Reader

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Abstract

IoT (Internet of Things) is a giant network of interconnected devices that are used to obtain data from the physical surroundings and share it among the network of connected devices that perform a specified task based on that data. RFID (Radio Frequency Identification) devices are one of the aforementioned devices that help IoT to obtain user data.

Using these technologies as a backbone, our goal is to develop a system that enables its users to order food by themselves and thus constitutes a self-ordering system. In order for us to implement this, we require hardware devices along with efficient software programs. The development of such a system thus can be divided into two steps, i.e. (i) development and integration of hardware required for the system, which includes an Arduino Uno microcomputer, RFID tags, RFID reader, and Wi-Fi (Wireless Fidelity) Module. (ii) Development of software that interacts with the user as well as with the hardware in order to fulfill the requirements of the system. This includes various web development frameworks like react.js, node.js, machine learning algorithm for prediction of estimated time of arrival (ETA) of orders.

Keywords:*IoT (Internet of things), RFID (Radio frequency identification) chips, RFID readers, Arduino Uno Microcomputer, Wi-Fi Module, ETA (Estimated time of arrival) calculation algorithm, Machine learning.*

1. Introduction

We all have been in situations where we had to wait in long queues to order food and we have faced various problems like people breakingthe queue, communication problems while ordering food, problems with cash transactions, and a lack of queue while waiting for the order. We all have wished we could order food by ourselves and not having to wait in queues while our food is getting ready. In order to deal with such problems, we have proposed a system that allows us to order food by ourselves and it is similar to the self-servicing kiosk machine as shown in Figure 3, being used by McDonalds at some parts of the world. The proposed system allows the user to order food without any hassle, and also eliminates all the aforementioned problems in addition to providing other significant benefits. The proposed system is expected to do so by utilizing the technology already available to the users: RFID (Radio frequency identification) chips in their ID(Identification) cards.The keychallenge in implementation of such a system is the availability of a kiosk machine on top of which the application is designed to run. This can be easily solved since everyone these days are utilizing RFID tags in some capacity and they require a similar machine for dealing with RFIDs'.

An IoT(Internet of Things) ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments.The major hardware we require here are RFID reader and a microcomputer. The code to retrieve the data from the RFID tags will be run by the microcomputer, and data obtained from it can be sent to a server or a cloud platform and can be utilized as per requirement for the application.

The ETA (Estimated time of Arrival) algorithm that is used to provide an estimate as to when the orders will be complete, we are using multiple linear regression predictor to take in attributes such as time between ordering same kind of food, time of day, chefs available and the general traffic. The output is an estimate of the time, which will be changing based on the new data obtained every week by the application.

May-June 2020
ISSN: 0193-4120 Page No. 4268-4272

The remaining of the paper is sorted out as pursues:Section II provides the reviewof work done in building systems that utilize RFIDs' to implement some functionality. Section III highlights the theoreticalbackground of the proposed architecturefollowed by results and discussion in Section IV.The conclusion and future work are talked about in Section V. End and future work bearingsare referenced in Section VI.

2. Literature Survey

The paper[7] talks about the potential that RFID enabled systems possess and that they can become integral part of every industry in the future due to their tracking capability to locate equipment, supplies and people in real time. The primary purpose was to identify common applications, potential benefits, barriers and critical success factors that make it so imperative for us. The findings suggest that things hindering massive adoption of such a technology are technological limitations, interference concerns, prohibitive costs, lack of global standards and privacy concerns.

The paper[3] also expressed major privacy concerns and has provided us with solutions that could address those issues.The authors of the paper say that identification and data collection are the two major privacy concerns surrounding the usage of IoT enabled systems. They have suggested two major solutions for these problems: one is the anonymization of user data that would reduce the risk of data identification and second is the transparency and auditing of the company in-charge of such data collection preferably every 6 months.

Theliterature in [6] talks aboutfixing one of the issues raised in paper [7]. It particularly talks about fixing the lack of global standards issue faced by interfacing of many devices in an IoT ecosystem. Seven standards development organizations across the world have initiated a global project called oneM2M (Machine to Machine).The main aim of oneM2M isto pursue a single horizontal service platform for exchanging and sharing data among IoT applications that can be used in various industries providing smarter IoT services to users. This global initiative so far seems to be a promising step towards solving the interoperability issues faced by many devices connected to an IoT.

The paper in [4] talks about the various attacks that RFID enabled IoT technologies are susceptible to, such as physical attacks that include tampering, signal jamming, tag removal and wireless zapping. Software attacks such as SQL (Structured Query Language) injection, virus or malware injection and such. The countermeasures to such attacks are provided in detail in the paper which involves reverse engineering a solution to the above discussed problems, by implementation of such measures we can also use RFID enabled IoT technologies in our applications with the confidence that it would not violate the CIA (Confidentiality, Integrity, Availability) triad.

The paper mentioned in [2] talks about the worldwide popularity of the RFID based systems and their unique approach towards security of such systems by using a hash-based RFID authentication. The work primarily focuses on secret session keys to generate hashes. By doing this, we can ensure that the data from the RFID tags is not corrupted by physical or software attacks. This novel approach is only useful to see if data is authentic or not. IoT privacy concerns are still not addressed by this implementation.

This paper in [5], contains the results of an extensive research study conducted on the usage of RFID technology in organizations and its impact on the efficacy of the organization. The research was conducted by considering the library of the Academy of Arts in Iran, to see how RFID tags affected the day-to-day operations of one of the biggest Iranian libraries. The authors considered various research variables such as service provision, costs, customer satisfaction and response time. Their findings indicated that there is a positive relationship between technology usages at the IAA (Iranian Academy of the Arts) library with an improved service provision, enhanced customer satisfaction and reduced response time.

The paper mentionedin [1], has proposed a system that seeks to improve the lifestyle of people through technology.Specifically,it talks about using RFID tags in vaccine cards instead of paper in order to easily track the vaccination cards and eliminate the delays and mistakes associated with using these paper-based vaccine cards. According to the research, this has enabled the availability of crucial information to those who need it more quickly and accurately. Such a system is the focus of the future and that is the reason why RFID tags are gaining the popularity as a disruptive technology.

The paper in [9]stresses the importance of having a minimum sample size when we are dealing with multiple linear regression. Without a minimum sample size suitable for the application in question, the predication obtained from it can be severely flawed. The paper states that it found that there is no fixed number for the minimum samples as it is completely dependent on the number of attributes considered for each problem and the application in question. Hence it is necessary for us to understand each attribute's significance to the regressor and choose accordingly. A minimum sample size thus becomes imperative for any application to make proper predictions.

The literature in paper [8] states that there is anintercorrelation that exists between the predictors (attributes) that would undermine the interpretation of MLR(Multiple Linear Regression) weights in terms of predictor contributions to the criterion. That is why it is important that we understand the significance of each and every attribute that the model is bound to utilize for making its predictions and that there is a strong need to address such correlations before they can have a negative

May-June 2020
ISSN: 0193-4120 Page No. 4268-4272

impact on our predictions. Experiments has to be made while choosing the attributes for the model and adjust the model parameters accordingly.

Any correlation found has to be addressed so we can use techniques for attribute creation or attribute elimination based on the degree to which they are correlated.

3. Methodology

The primary objective of our project is to build a Food Ordering system, which can be used by anyone who want to order their food without any inconvenience of waiting in long queues, without any hindrance due to language barriers, an application having a self-ordering appeal and a faster payment system, and an algorithm to predict ETA (Estimated time of arrival) of the order. The input for this project is the user input which would first require the user to scan their RFID (Radio frequency identification) tags and then providing input as food of their choice.The output is the token generated along with an ETA which is sent as a text message to the users' mobile devices. The proposed architecture for developing this system is given in Fig 1. The modules used in the methodology includes– Hardware Module (includes RFID tag, Arduino Microcomputer and RFID scanner), Display Module (Kiosk machine), Server module, Database Module, and finally ETA generation algorithm.

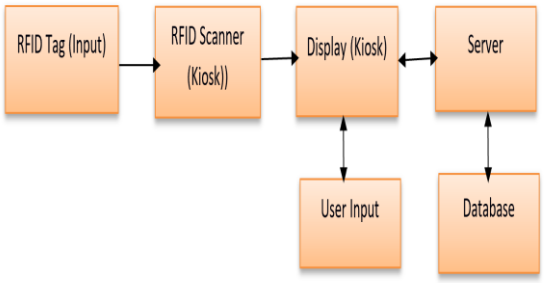

Figure 1: Architecture of the project

A. Input

The input is the RFID chip equipped ID cards provided to the students. They are going to scan these ID cards at the RFID reader terminals present in the Kiosk machine. The reason for using a Kiosk machine is that it is capable of handling multiple functionalities such as scanning RFID tags, a Display unit, a Database and a Server Unit.

B.Hardware Module.

The hardware module consists of an Arduino Uno Microcomputer (for prototype only. Original application runs on Kiosk machine using whatever hardware capabilities that the machine has). The reason for this is that it is flexible, cost effective and contains many open-source third-party libraries that provides useful functionalities required by the application. An ESP-8266 low cost Wi-fi microchip for transmitting the data to a server and a passive RFID chip that is detectable at 930 KHz by a RFID reader. The passive RFID tag is cost effective and resistant to signal jamming attacks, SQL (Structured Query Language) injection attack and virus or malware injection attacks.

The RFID data received is a unique 16-digit hexadecimal number.

The prototype of the connected hardware is shown in figure 4.

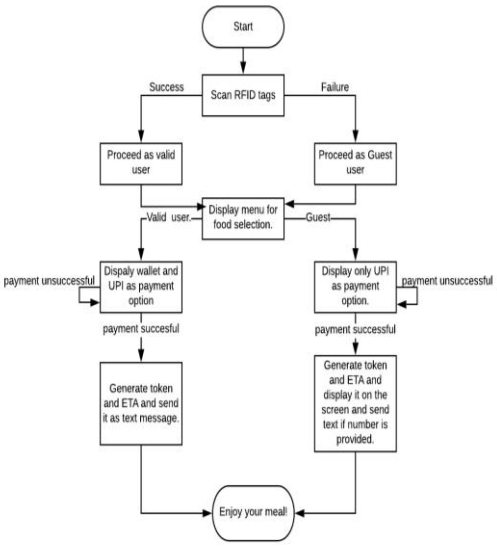

Figure 2: Flowchart illustrating the workflow of the project.

Figure 3- Example of our target deployment platform (McDonalds Kiosk Self-servicing machine), (Courtesy: Upi.com)

B. Display Module

The flow of the processes involved while using the system is shown in fig 2. According to this, all the customer interaction with the system is possible because of the display module. The display module contains all the necessary UI/UX elements required bythe application. The entire front-end of the application is written using

May-June 2020
ISSN: 0193-4120 Page No. 4268-4272

JavaScript library React.JS, which is way more powerful than vanilla JavaScript. The Welcome submodule greets the user and asks for authentication. After Authentication the user is provided with all the menu items for the day. After making a selection, the user is directed to the payments page. The payment option is either UPI(Universal Payment Gateway) or a Wallet option (only for registered users), which can be pre-loaded with cash for faster transaction. The display module relies on ReactJS virtual DOM (Document Object Model) for smoother user experience. There is a separate UI (User Interface) for the chefs which displays all the pending customer orders on their screen. Once they have prepared the food, they can select finished, and a notification is sent to the user on their mobile devices. The chefs' also have an additional screen to add the items available for the day so only those items are displayed for the users.

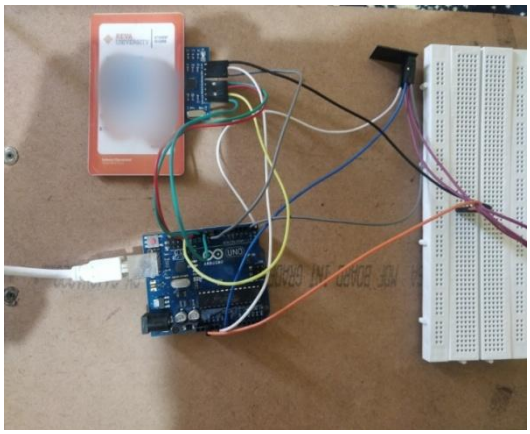

Figure 4: Prototype developed based on our hardware design.

D. Database Module.

The database module consists of the database we are going to use forimplementation of proposed system. We have used MongoDB NoSQL (not only SQL) database over traditional SQL(Structured Query Language), because it has faster database retrieval speed and it can store various types of data. The faster retrieval speed is due to the no sequential storage, flexible storage rules and the usage of internal memory for storing the working set of data. The data obtained from the RFID (Radio frequency identification) tag is a 16-digit unique Hexadecimal number. The mapping of this RFID unique code to User data is present in the database, which is retrieved for authentication. It also contains the fooditems that is available for the day and all the required pricing along with it.

E. Server Module.

The server module is the most important module of our application. It contains all the essential functionalities required by the application. It contains code that authenticates the user, retrieves available menu from the database and displays it. It also makes use of various APIs' (Application Program Interfaces). The razor pay API for payments, the SMS API for sending text messages to users mobile devices, the wallet API designed to provide the wallet feature for users with RFID tags, and also runs the machine learning algorithm to generate ETA (Estimated time of arrival) for the orders. The server implementation we decided upon was node.js server because it is faster than other server implementations currently available and has easy integration capability with ReactJS used in the front-end of the application. Node.js also provides options for asynchronous operations that enhance the speed of the system.

F.ETA estimation algorithm

The ETA (estimated time of arrival) algorithm is based on the multiple linear regression predictor model. This machine learning model works by taking in multiple attributes as aindependent variable and outputs a single prediction (in out case, estimated time for preparation of food) also known as the dependent variable. Our algorithm uses four attributes as independent variables. They are, time difference between ordering of same food (used because if same food is ordered within few seconds, ETA will be same for both the orders), Traffic at the moment of ordering(number of pending orders), time of day (taken in 1 hour intervals) and the number of chefs' available. The algorithm depends on all 4 of these attributes but the significance of each of these attributes is determined by the co-efficient of each attribute. The general formula for MLR (Multiple linear Regression) is $y = b_0 + b_1x_{i1} + \ldots + b_px_{ip.}$ Here $b_0$is the bias which is a constant that is added to every prediction to balance for the bias of the coefficients. The $b_{1 \ldots} b_p$are the aforementioned coefficients that contain the factor to denote the significance of each variable in the final outcome of the problem. One important thing to remember while implementing this model is to avoid too many attributes to consider for prediction as this severely hinders performance of the predictor. That is why we have chosen only 4 parameters we thought were absolutely necessary for the predictor and eliminated remaining parameters. The output of this algorithm will be an approximate of the time needed to prepare the order. The algorithm is also trained on a weekly basis with new data to increase the accuracy of the predictor.

4. Results and Discussion

The results of the system are as follows:

1) RFID card reader scans for data when the RFID tag is in very close proximity to the RFID card reader. We arrived at this result after we tested the RFID reader for reading tags at different distances. This prevents the system from doing multiple scans because people need to be in close proximity for the card to be read.

2) User Interface(UI) is implemented according to the specification. We arrived at this result after we implemented the display using web pages developed using React.JS. React.JS unit testing allowed us to

May-June 2020
ISSN: 0193-4120 Page No. 4268-4272

evaluate single components such as Payment, MenuItem etc., we got a 95% test coverage using react testing library and we also did an automated testing using cypress and got an 80% test coverage.

3) The database of the system is fast enough to handle large requests at the same time. We arrived at this after testing the database with thousands of dummy data and the retrieval speeds were within milliseconds.

4) The server is capable of handling requests,more than the current required capacity. We arrived at this after we tested the server by overwhelming it with requests and the server crashed after a number of requests, that is more than our required capacity.

5. Conclusion and Future Work

Our primary goal is to development of a system that enables the users to order food by themselves and also to eliminates aforementioned problems.We have studied all the necessary technologies required to build an IoT enabled system and also about machine learning models that does prediction. This model even though does not require high computational capabilities, having moderately high capabilities will certainly improve the speed of the whole process. The system canbe extended by adding different functionalities like scheduling of orders ahead of time where users can order food in the morning if they require it in the afternoon. The future work on this system can be further extending it for self-checking out of books from library, and also use it for authentication for fee payment, automated parking and billing system etc., by utilizing the functionalities already present in the system and are common with our application.

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