Helping Local Businesses by using IoT Embedded Systems

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***Abstract*— In today's world, businesses require a large amount of data to be gathered about their customers, which is then analysed to help optimize business decisions to increase sales and profits. Multinational companies spend large amounts of money annually on gathering demographic information about their customers and developing methods to analyse it. In this paper, we have designed prototype embedded systems that can help businesses to improve without having to take a major risk and is cost-effective.**

***Index Terms*— IoT, AI, Embedded system, Customer, business, Android, Database**

I. INTRODUCTION

Businesses are essential to any economy, and every major chain of stores was once a local business in their own country. In India, it's said that all the Indian family-owned companies have been contributing to almost 70% of India's GDP. A local business is significant to a developing country like India, providing jobs and stimulating the economy. If American companies come to India, even though they are creating jobs, the profit is sent back to the US stock market. It helps to stimulate the economy as more money comes in from another nation.

In the case of local businesses, all money is kept within the country, allowing local company owners to spend that money elsewhere and help stimulate the economy. As technology progresses, the problem with local businesses is that they need to catch up with big international companies with technology that allows them to maximize their profit in multiple ways. Companies like Burger King, McDonald's, Pizza Hut, and Domino's, which are trendy fast-food restaurants, have been using technology to improve and make their company maximum profit. Dominos uses GPS to track its employees to maximize labour efficiency and profit. Google and Netflix have been using ML algorithms to recommend the best customer experience, maximizing profit. Technology is even used in colleges nowadays; the best example is the attendance system used by the college to keep track of their faculty and staff.

Most people in India are scared to take significant risks; that's why we can say India is among the countries with the highest fixed deposit amount. So even when an Indian family wants to take the risk of starting a business, they try to limit their risks by being cost-efficient and not trying new techniques to improve their business. Most Indian companies are still working orthodoxly; the only significant difference is the UPI system. We want to change that by building a very cheap system that does not seem risky and is easy to use for anyone. We will make it simple but efficient so that even though it has little change, it will change for more profit in the longer term.

II. LITERATURE REVIEW

A. AI and IOT use in Business

Artificial intelligence is helping businesses grow exponentially with the aid of IoT or the Internet of things, making business work swiftly in modern times. These devices are quicker than humans and are crucial for profitability. They are easy to assemble and maintain.

Technologies make life easy for us, and this work aims to help small businesses make great profits. Internet of things majorly means connecting small devices to the internet so they can be operated from all around the globe.[8] It is basically connecting sensors with the help of micro-controllers so as to work smartly with these physical objects. Communication is easy to establish with the internet, the connection is permanent and data is rendered regularly. IoT is perfect for automation purposes.[10] The user can control the switching of lights, intensity of light in a room, build a driverless automated car and what not. The system is cheap and easy to operate, with reduced response time IoT increases productivity and efficiency, reminding users when maintenance is required, thus avoiding any failure in the system. It has great opportunities for revenue generation. With widespread penetration of the Internet of things, there is an excellent scope for future development and home automation and connected industries. Less human labour is involved, thus letting employees to focus on the designated work. The system's efficiency increases drastically when IoT is enabled with Artificial Intelligence and Machine Learning. [5]

B. Smart Security

Without security, individuals often become complacent and miss the unusual behaviour of civilians, employees, and others around them. Awareness is an ongoing activity, and people want to do the right thing, so security guides a positive and proactive culture. That's why we require their introduction of smart solutions to them, where a smart security system has been introduced. In this system, where there a microcontroller or microprocessor in the middle that act as the brain of the system then you act various senor and locks to help secure the place entry of an unauthorized person into places like a house, shop, even bank, and other institutes[9]. The whole purpose of the system is to not be operated on a daily basis by humans but rather be automated, as it is more cost-effective and even safer than a human being. This machine will be also working 24 hours a day, only required initial cost, power supply, and maintenance once a week or wherever broke rather than having to hire multiple security guards and having to pay for them to watch the system. Various research papers have used Arduino as the central brain of operations, as it is very cheap a microcontroller and easy to use and maintain. [4]

One of the ways to make smart security was built by using Arduino as the central brain and securing the house using a keypad lock, solenoid lock, and temperature sensor. In this system, they made so the door open only if you had put in the right password and you are given the right signal in the solenoid lock.[13] A solenoid lock is a lock that is operated by an electrical signal and relates on electromagnetic force to open the door. They have used electromagnetic force, like keycards or similar, which send electrical signals to the solenoid lock to open up the system. In the system, there are is two cases when a person wants to open the door, one is when they had put the right password in the keypad lock, and the electrical signal sent to the solenoid lock then the lock opens up.[6] Otherwise even if one of them is wrong or both are wrong then the system sends a notification to the owner asking whether the person is the owner or not, if the owner replies no, then there option of calling the police.

The temperature sensor is used similarly to the flame sensor we planning to use as it focuses more than just security but also gives an alert when the place gets a bit hot or cold, which can be used for a comfortable style of living. It will alert when too high temperature considers a fire, and it will alert the owner of the risk of their place being on fire, and give them the option to call the fire station or see the place for them and react accordingly. Another benefit of the temperature senor was you could find the temperature sensor of the place according to according either your air conditioning or heater depending on temperature and make the place comfortable for yourself while being at home or while coming back home.

Systems for fire alarms are crucial for warning people before a fire consumes lives and property.[12] It's crucial to have a responsive and effective system so that the fire station may be notified first in order to have a quicker alerting system. If there is a fire and it spreads to the entire building. By suggesting a fire alarm system that can contact the owner remotely to alert them if there is a fire at their property.

Some classical fire alarm systems like the "NestProtect" [3] connect the user and sensing module through Wi-Fi, whereas this system creates a sensing module that will be connected through IoT and Cloud Messaging. The system was designed to alert, monitor, and handle real-time accidents. Notification to the user and fire station will be sent immediately. Helping small businesses to grow to keep them safe from any sort of unforeseen situation is essential to install this system.

III. Hardware Description

A. Raspberry Pi

We use a Raspberry Pi 4 computer as a server. The Raspberry Pi 4 is a cheap credit card-sized computer that can also act as a microcontroller. One can even use it as a complete replacement for a laptop. This device component detects the flame detection sensor signal and Passive Infrared Red Sensors on receiving further necessary action. I am using a Raspberry Pi 4 computer to detect the signal and automatically send the signal over the internet. I wrote the script that handles this operation in Java. The Raspberry Pi 4 doesn't need to be connected to any other computer for the project's operation and only needs to be connected to a power source, as it has its wireless communication equipment [11].

B. Flame sensor

This is a flame sensor PCB that is based on a YG1006 NPN Phototransistor. It consists of 3 pins, which are for 5V input, ground, and digital output. It has many surface-mounted devices on it, such as a 10-kilo ohm potentiometer for controlling the sensitivity of flame detection and an LM393 Voltage comparator IC. The working of the flame sensor is based upon the LM393 and the phototransistor. When there is no flame in the range of the phototransistor, the LM393 produces a HIGH digital output. When light in the range of the flame is produced in front of the phototransistor, a voltage is produced in the base terminal of the transistor. This causes current to flow from the collector of the circuit to the emitter of the circuit, reducing the potential at the LM393 which changes the digital output of the flame sensor. This digital output signal is sent to pin 18 of the Raspberry Pi 4

C. Passive Infrared Sensor

Passive Infrared which is used in this project, is also called motion sensor. It consists of 3 pins, which are for 5V input, ground, and for digital output. The word Passive in Infrared Sensor tells us the about the sensor being inactive. It rather focuses on Infrared that is emit by human body, and detect it. The required of senor was to count people coming in, and the decoration of Passive Infrared Senor match. PIR has two slots. These holes are constructed from a unique, IR-sensitive substance. The Fresnel lens is utilised to ensure that

the two PIR slots can view beyond a certain range. A human body will block the first slot of the PIR sensor when it passes by. Positive differential change results between the two slots as a result of this. The sensor generates a negative differential change between the two slots once a human body leaves the detecting region, changing the digital output signal. This digital output signal is sent to pin 15 of the Raspberry Pi 4.

D. Google Firebase Cloud Messaging

This is the service that app developers use to send notifications to the users of their apps. Essentially, all Android and iOS devices have a direct connection to Firebase servers, allowing them to receive notifications from apps instantly with low power and performance consumption.

When an App Developer needs to send a message, data or a notification to a user while their app isn't open, rather than sending the message directly to the user's device; instead, the app developer sends a letter from their own server to Firebase. Firebase then relays the message to the user or users to which the message was to be delivered through the persistent connection that the android device has to the firebase servers. This allows all app developers to be able to send notifications regarding their apps to the user without any usage of power or performance.

E. Android App Client

This is an Android app that I have written which receives notifications from the Raspberry Pi. The app needs to be opened one after it is installed. This registers the device to be able to receive notifications from Firebase [7].

F. Database

The database is used to store information about the registered business locations, such as the username and the encrypted password hash used to login by the application client by that location. It also stores the information gathered by the sensors located at the business location. We are using the Cloud Firestore NoSQL cloud database service provided by Google. This can allow multiple business locations to simultaneously access as well as upload new data to the database simultaneously. We can also develop a client for the restaurant chain to read the data presently stored on the database of all locations, as well as register new locations to the system.

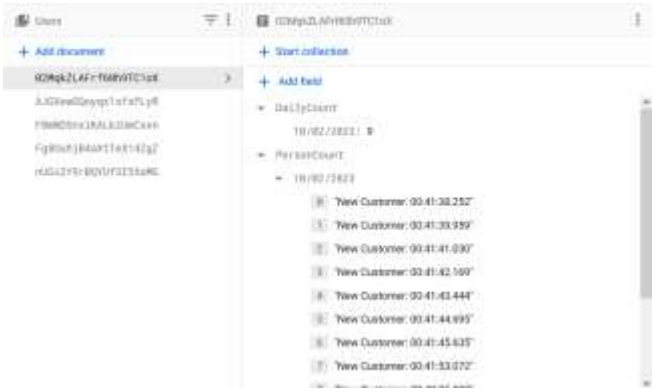

Fig 3.1: Firestore GUI showing the stored customer data of a restaurant.

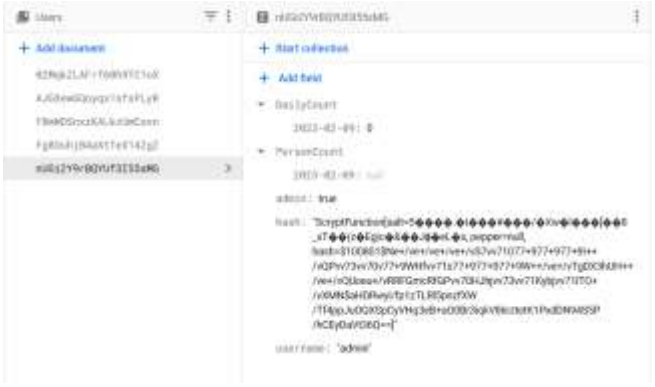

Fig 3.2: Firestore GUI showing the stored authentication information of Admin User, with encrypted password hash.

IV. IMPLEMENTATION

Currently in the project we have 5 Java classes which define various objects and methods that the project needs to work on the IoT embedded system running on the Raspberry Pi.

A. The Main Class

The **Main** class contains the main() method of the project which is the first thing that runs on the JVM when we run the program. It invokes the different functions that are defined in the other classes. This helps keep the program modular which allows us to add or remove various functions as the project progresses. For example, if we were to implement a Graphical User Interface then we would use the main class to invoke the functions responsible for drawing the interface windows. If we were to create a web client then the main class can be used to simultaneously launch the web server used to host the website along with the project.

B. The init Class

The **init** class stores the initialiseFirebase() function which is used at the startup of the program to sign in to Google Firebase from which we use the Google Firestore database

service as well as the Google Firebase Cloud Messaging service. There is a private file 'serviceaccountkey.json' which contains the required private API keys for logging in to the Firebase service that we have created for our project. Anyone who wishes to use our project must first register and obtain their own Firebase Service Account API keys for using our code. The function reads the API keys and logs in accordingly.

C. The User Class

The **User** class which defines the User object. Each User object has its own username and encrypted password hash for logging in to the system. It also has an admin property which is used to separate between normal users and administrators, or in our case to separate location management and chain management. This is important as both have different uses of the project available to them. The location management should be able to view data for their own location while the chain management should be able to view data for all of the locations. The chain management also has the ability to create or delete accounts as necessary. The User class also has the DailyCount property which is a map of a date String and Integers used to store the date and number of persons that visited that location. It also has the PersonCount map which stores the timestamp of every new customer which was detected by the sensor. It has two methods addcount() and viewCount() which are used for adding and viewing the customer data of that user.

D. The User Database

The **UserDatabase** class which is used as a login system and to store and manipulate User objects. The main() function loads this class which then starts by displaying a screen asking for the username and password of a user through the loginscreen() method. If a user with authentication level 1 logs in then the databaseRestaurant() method loads with that User class as its argument. This method lets the user choose between Viewing or adding customer data for their own restaurant as shown in the use case diagram. At the start of this method it invokes a PersonCounter object which is then run as a separate thread in the background.

If a user with the admin Boolean value as true logs in then the databaseAdmin() method is invoked with that User class. This method contains administrator level options such as registering, deleting and viewing a list of users, and to view or add customer data for any of the registered locations.

There is also the userdatabase() method which is the method that the projects main() function invokes and this method acts as the main method of the class. It invokes the loginscreen() function which asks the user to input their username. After receiving the input credentials, the program queries the Firestore database to check if a user with the username exists. If that user exists, it asks for the password of the user and then uses attempts to find if it matches with the password hash stored in the database which was generated using the Scrypt cryptographic key derivation algorithm. On successful authentication, the information of the user is retrieved from the database and a User class is generated using the retrieved data. The function then according to whether the user is an admin launches the corresponding function.

E. IoT EmbeddedSystem

The **IoTEmbeddedSystem** class is used to communicate with the hardware component of the project. We are using a Raspberry Pi 4, Flame Sensor and a Passive Infrared Sensor. Flame Sensor is to detect the fire happening inside the store. Passive Infrared Sensor to detect motion and to count the number of people that are entering the business location. This project uses the Pi4J java library to communicate with the Raspberry Pi's General Purpose Input Output (GPIO) pins. It also uses the Firebase library, which we will use in the future as a possible security system. It implements the Thread for multithreading, as it runs in the background counting persons while the restaurant is logged in to the database. This class also uses the java.time library for using the time to determine when the business is opened and closed and when to add to the person count or to act as an alarm system . It also alerts in case of fire.

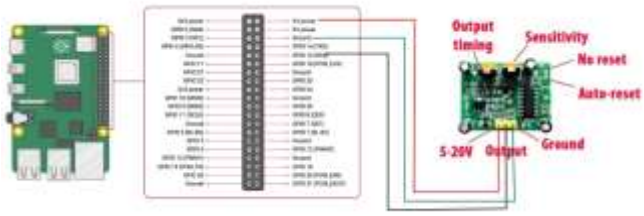

Fig 4.1 Circuit Diagram for Detecting System

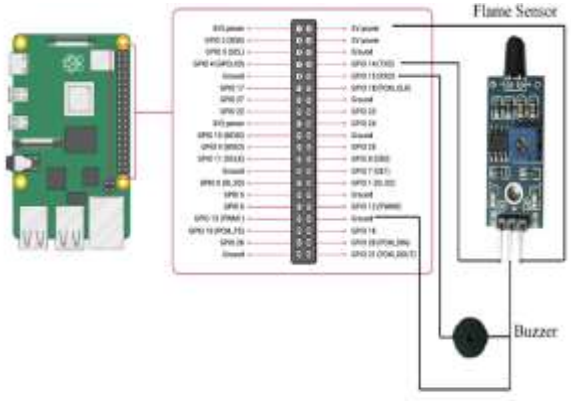

Fig 4.2 Circuit Diagram for Fire Alarm

F. Android App

The final major component of the project is the Android app, when run for the first time, registers the Android to Firebase. After this one-time registration, the phone will start receiving any security and fire from the system anywhere in the world through the internet. It also mentions how many people enter the store today, and a log of recent alarm events. It can be used to login to the Firestore database and view information logged on the system.

V. WORKING

As stated before, our embedded system has three functions and the results are below with function

1. The first function would be trying to collect data and use it wisely to improve company profit by helping utilize the data effectively. In these functions, we are ready with the collection of data parts. Every time a customer is detected the timestamp is uploaded onto the Firestore database.

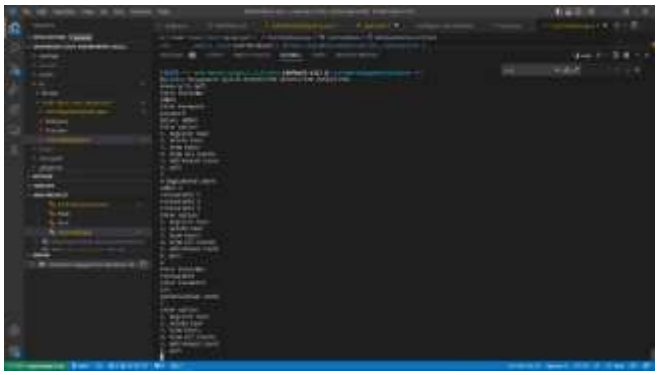

Figure 5.1 Chain Manager

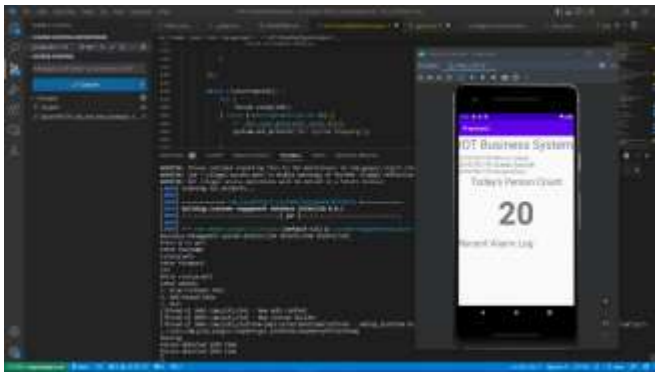

Figure 5.2 Store Manager

2. The Second function would be to create a security system. In these functions, we have made it, so that owner or store manager has put the time store will close. If the Passive Infrared sensor detects anyone coming inside the stores then it considers the person an invader. Then it notifies the Raspberry Pi and then an alert will show on the notification on the phone. The alert is shown as notification which is shown below, and it include the time when the person was detected by the senor.

Figure 5.3 Security Alert

3. The last function we required our system to do was to detect the fire. In the function, we use the flame sensor to detect the fire. If their fire detects the sensor send information to Raspberry PI, which then sends a notification to the phone of the owner or stores a similar security function. It also same a similar notification to the last function where it tells you Fire detection, and tell u the time it detects the time.

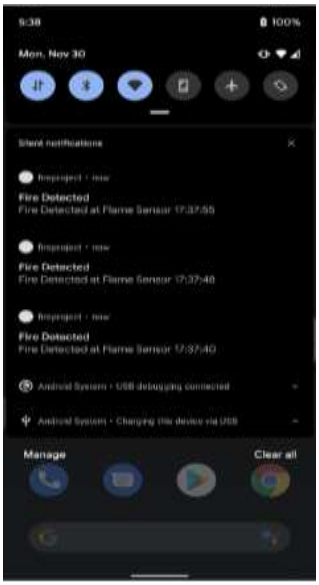

Fig 5.4 Fire Alarm alert

4. We have made our own application for the Android OS which receives alerts from the Embedded System through the internet. It is also able show the current customer count of that day.

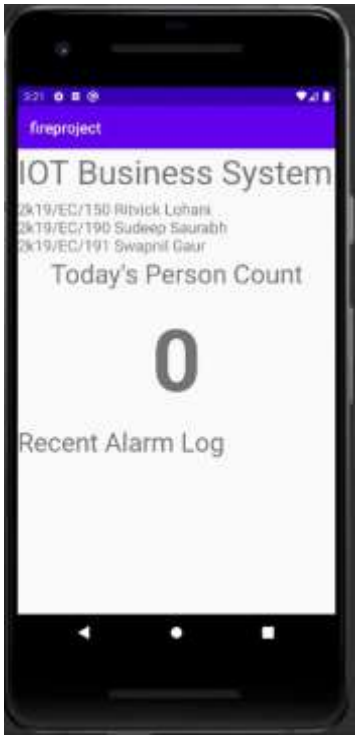

Fig 5.5 APP

VI. Conclusion and Future Scope

In today's world of technology, companies are investing billions of dollars annually on data and using that data to efficiently increase the growth of their company using methods which include optimizing the flow of customers, the supply and demand of the products that they provide. We have proposed a design for a low-cost Internet-of-Things enabled embedded system prototype which would help the small retail business to get data, and able to use that data further to increase its growth. The prototype is cost-efficient as it costs just under ₹2,500. The prototype currently works as data collection device which updates a remote database, as well as an emergency fire and security alarm.

The device is able to gather the number of people that visit a retail location and update a database in real-time, which can be viewed by the authorized user. Any data or necessary alerts are instantly sent to the mobile devices of the user who have installed and authenticated with the app we have made for the system. Many wonder what the applications are of the information gathered, and here are some examples:

1. We can determine and optimize the number of employees working at the location using this information. The device can accurately determine the customer footfall of the shop on an hourly and seasonal basis which helps decide the required number of retail employees, cash POS systems, security and safety measured required to be present in the retail shop at that moment of time. The retail shops should collect data over period of time, and see what hour of time during the day the shop is most active and they can have more employees present and that moment.

2.With the customer footfall information, the store can help identity various pointers on business as to why the growth of the business is doing well or not.

a) If the number of people visiting grows, and the growth of company profits happens at the same time, that mean that company is doing well.

b) If the number of people visiting grows, but the company profits and the item sales are not at a growth then that indicates that the company has been doing well with their advertising, but not with their product lineup or their pricing.

c) If the profits of the company grow, but the people visiting the store has been declining, this indicates that the company has been doing well with their pricing and has been selling desirable products, but not doing well enough with their advertising which can potentially be improved to increase sales.

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