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Pharmaceutical Dispensary System for Hospitals and Pharmacies Using Embedded System and Cloud Computing

SahayaSakila V, Aditya Rohan Das, Dhananjay Narayan, Yashaswi Rahut

Abstract*: The major current issue of access and efficiency for medicine supply in India can be resolved by providing medicine consumers with an automated distribution system which uses embedded system and cloud computing to work like an ATM. The consumers are provided with a special prescription that they can insert in the machine. Themachine verifies with database if the requested drug is in stock. The machine accesses its cloud storage to check the database using Amazon S3 (Simple Storage Service) or RDS(Relational Database Service). If the drug is in stock, the machine fetches the cost and furnishes the user with the payment options. After the payment confirmation, the machine dispenses the drugs and updates its database. Whenever a medicine or drug has been consumed, a notification is sent to thedistributer to provide refill.Some medicines are to be stored in optimal conditions to maintain their potency. The machine accommodates cold storage feature that monitors the temperature, humidity, UV radiation level and gas composition using sensors.If any of the parameter changes drastically, a notification is delivered to the supervisor. Using Amazon EC2(Elastic Cloud Computing) the machine analyzes the data it records and determinesthe patterns of frequency in consumption, the most and least used products in a region. This project aims to revolutionize existing health care systems by proposing a new adaptive drug distribution system that also addresses quality assurance, system design and benchmarking for quality improvement.

Keywords*: Pharmaceutical, Medicines, Drugs, Distribution System, Cloud Computing, Embedded Systems, Data Analysis, Healthcare Electronics

I. INTRODUCTION

According to a WHO report, a significant number of world's population do not have ready access to emergency medicines. Health facilities are abatedto the populations in small towns and the rural regions of many countries are largely unattended. [1]India is a geographically diverse country with variable climate conditions in different states. It makes the distribution process of the medicines cumbersome.

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The distribution process is long chain and the rate of brand substitutions makes it necessary for pharmaceutical companies to keep the stock available at all levels and at all times. Most of the brands in India have generic drugs and the retailers obtain huge profits from these generic drugs compared to the branded medicines. To abate the risks of substitution, companies must ensure products are made available to the pharmacies.[2]

Many pharmacists are untrained and due to the lack of the proper distribution of the branded medicines, people experience poor medical facilities. Also, the medical retail shops are not available at all times and some are closed during the national holidays and festival seasons. There are rarely a few pharmacies on national highways, which is a major deal in cases of emergencies. To deal with such situations and to ensure proper distribution of medicines to the public in India, we propose an automated distribution system using Cloud computing features and embedded systems, that can be placed in remote villages where there are no timely drug supplies and also in cities and at regular intervals in major highways of India. This machine also maintains the optimal conditions under which the medicines have to be kept.

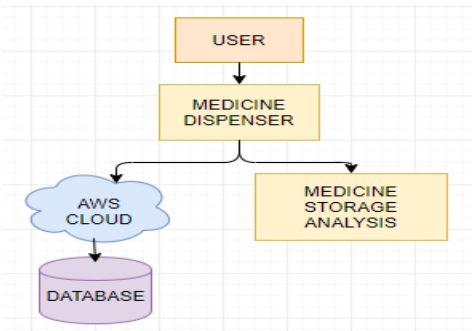

Fig. 1 Flow Diagram for Medical Dispensary System

II. EXISTING SYSTEM

In India, the most common drug distribution systems are retail stores and the pharmacies. The various types of pharmacies include Community pharmacy, Hospital/Clinical pharmacy and Ambulatory pharmacy. These pharmacies always require trained pharmacists at all times when open. Also, many of the pharmacies lack proper storage and do not have temperature and humidity monitoring facilities. These pharmacies are expensive to maintain and also are unavailable at all the times.

These pharmacies use different versions of the same medicines manufactured by the different companies. The consumers are not aware of all the recognized brands and how much their actual cost is. The use of software like SAP and SAS, apart from other customized software, is increasing in some of the pharmacies. However, the adoption of technologies such as radio-frequency identification (RFID) has been slow.

III. PROPOSED SYSTEM

We propose to tackle the issue of access and efficiency of medicine distribution by providing the consumers with an automated distribution system which uses embedded system technology and cloud computing to function in a similar manner as an ATM. The consumers are issued a special prescription with Bar codes and QR codes that they can place inside the machine to get the prescribed drugs.The machine checks the database to see whether the required drugs are in stock or have been exhausted. The machine can access its cloud storage to check the database using Amazon S3 (Simple Storage Service) or RDS (Relational Database Service). If the requested drugs are in stock, the machine then conveys the cost and provides the user with multiple payment choices. After the payment is verified by the system, the machine dispenses the drugs and updates its database about the quantity.The cloud storage will hold a database for every individual unit of the dispenser. Whenever a particular medicine or drug has been depleted or is not present in the dispenser a notification is sent to the hospital/ distributer to request refills.

Also, certain medicines need to be stored under optimal conditions to ensure that they do not lose their effectiveness and potency. Our prototype of the machine contains a special cold storage feature that monitors the temperature, humidity, UV radiation level and gas composition using sensors that are collectively interfaced with a Node MCU ESP8266.If the temperature or any of the other parameter changes drastically then an immediate alert is sent to the supervisor. The parameters are recorded on database.

Using Amazon EC2(Elastic Cloud Computing) the machine can analyze the data it records and determine the trend of frequency in consumption, the most and least used products in a selected region.

IV. SYSTEM ARCHITECTURE

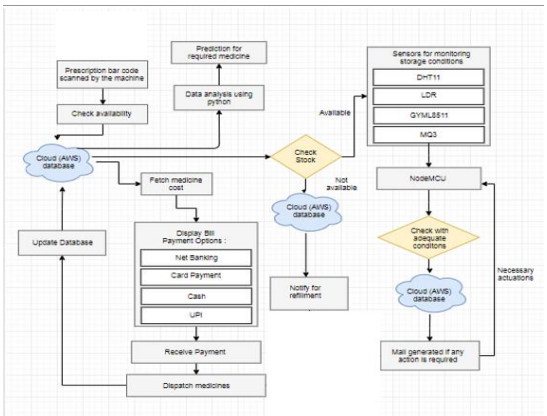

Fig. 2 System Architecture Diagram

The above diagram is a complete representation of how the system functions and the various stages and components involved. The prescription which the doctors hand over to the patients, unlike traditional handwritten prescriptions has a barcode or a QR code which represents the prescribed drugs.The prescription can even use Optical Mark Recognition (OMR) to represent the prescribed drugs.

Stage1: This special prescription can be inserted into a slot in the machine where it is scanned and converted into machine understandable format. The dispenser is connected to a Cloud database like Amazon RDS where it stores all the data on the drugs present within the dispensary and checks for availability. If the machine finds a particular medicine has reached its expiry or a lack of a particular type of drug within the dispensary the database is immediately updated and the assigned supervisor or supplier is notified. The database iskept updated whenever any drug exists or is added to its particular storage containment. Using tools such as Amazon Kinesis data is captured, stored and made ready for processing. Amazon Kinesis makes it easier to collect, process and analyze real-time streaming data so that the user can get timely insights and react quickly to new information. Thedata which is collected and stored can be used for predictive analysis and recognize patterns in consumption of drugs in a particular area. Most of these operations can be performed by feeding information gathered to applications that run on AWS Lambda. The machine displays the prescribed medicines to the user on its screen along with the bill. The user if is provided with a list of payment options from which they can choose and once the machine receives the payment it dispenses the drugs along with a printed receipt. Simultaneously, the database is updated and the transaction is recorded. The dispenser also sends a notification to the users which contains the details of the purchase.

Stage 2: Using various inventory management software available on AWS the cloud database can perform frequent checks to ensure that the stock for each drug is maintained. If a shortage in supply is detectedthen a notification is sent to the supplier to provide a refill. Using software such as RestockPro and Sellics the database can detect certain red flags such as quicker depletion of inventory and higher volume of orders. In such cases the system predicts a surge in consumption and assigns pre-orders to maintain steady supply.

Stage 3: One important aspect of this dispenser is storage. Most drugs need optimal storage conditions so that they remain effective and don't loose their potency. This can be ensured my making sure that the drugs are stored at the right temperature, humidity and away from direct radiation. In order to ensure optimal conditions are maintained the dispensers are equipped with special air tight storage compartments which are fitted with sensors that monitor specific parameters like temperature, humidity, light intensity, pressure and gas composition. These sensors are interfaced with a NodeMCU ESP8266 development board. This development board is capable of sending real-time data to the cloud where it is stored and analyzed. If any of the parameters cross their optimal limit thenthe supervisor is immediately notified with a warning.

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This warning mechanism helps ensure quality control and reliability.

V. MODULARIZATION

A. Module 1: User Interface

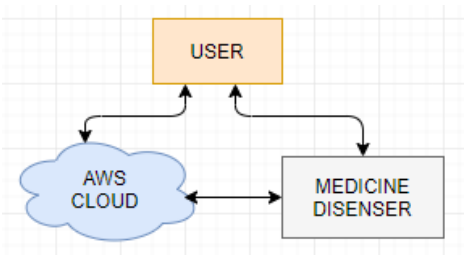

Fig. 3 User Interface Model

This module is used to present the relation between the user, AWS cloud and the dispenser. A detailed account is maintained for each user within the cloud. Every transaction is recorded and maintained so that it is easily available to the user when needed. Details such as drugs purchased, amount, cost etc. is kept confidential and is visible only to the user(i.e.patient) and the doctor who assigns the prescription. Every time the user accesses the dispenser he/she can view their account details and transaction history.

B. Module 2: Cloud Computing

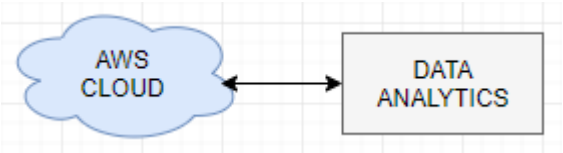

Fig. 4 Cloud Computing Model

The dispenser is connected to a Cloud database like Amazon RDS where it stores all the data on the drugs present within the dispensary and checks for availability. The database is kept updated whenever any drug exists or is added to its particular storage containment. Using tools such as Amazon Kinesis data is captured, stored and made ready for processing. Amazon Kinesis makes it easier to collect, process and analyze real-time streaming data. [3] The data which is collected and stored can be used for predictive analysis and recognize patterns in consumption of drugs in a particular area. This data can be used to study patterns of consumption, predict spread of diseases in an area, analyze a patient's medical history to study illnesses, etc. using machine learning on the data. Most of these operations can be performed by feeding information gathered to applications that run on AWS Lambda.

C. Module 3: Embedded System

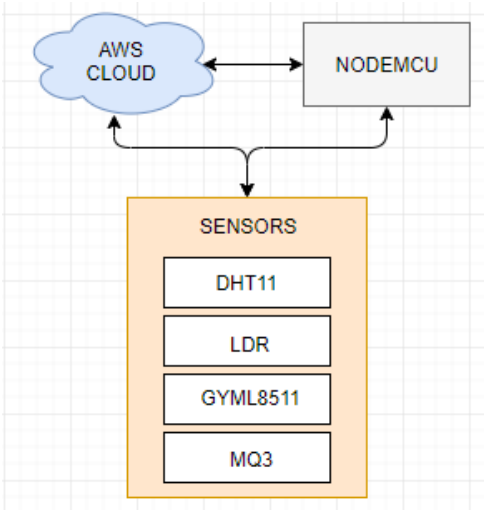

Fig. 5 Embedded System Model

The above diagram represents the embedded system technology used by the dispenser. Most drugs need optimal storage conditions so that they remain effective and don't loose their potency. This can be ensured my making sure that the drugs are stored at the right temperature, humidity and away from direct radiation. In order to ensure optimal conditions are maintained the dispensers areequipped with special air tight storage compartments which are fitted with sensors that monitor specific parameters like temperature, humidity, light intensity, pressure and gas composition. These sensors are interfacedwith a NodeMCU ESP8266 development board. This development board is capable of sending real-time data to the cloud where it is stored and analyzed. If any of the parameters cross their optimal limit then the supervisor is immediately notified with a warning. This warning mechanism helps ensure quality control and reliability.

NodeMCU ESP8266

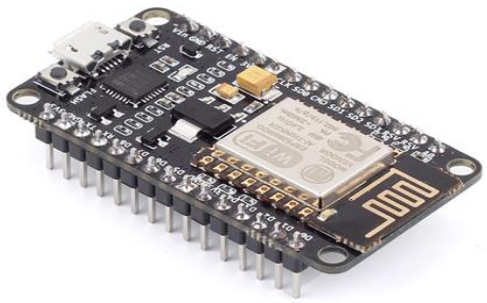

Fig. 6 NodeMCU

This development board is used to send the sensor data to the cloud database with the help of the inbuilt ESP8266 Wifi module which is connected to the internet. NodeMCU is a Firmware on ESP8266 and serves as a SoC(System on Chip). This module comes with a built in USB connector and a rich assortment of pin-outs. The NodeMCU has various digital and ADC(Analog to Digital Conversion) pins that are used to interface the board with the sensors.

Sensors

1. **DHT11**

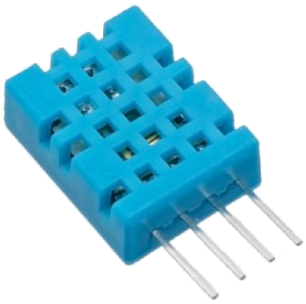

Fig. 7DHT11

The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin.

2. **LDR-Light Dependent Resistor**

Fig. 8 LDR

LDR is used to measure light intensity. It is an analog sensor. An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. The resistance of the LDR decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. The live pin of LDR is connected to an analog pin and 5V via resistor and the other is connected to GND.

3. **GYML8511**

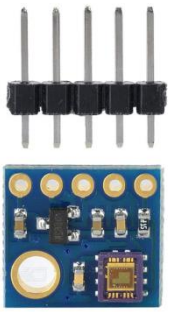

Fig. 9 UV radiation sensor

This sensor is used to measure UV radiation which helps us ensure that the drugs are not under direct sunlight.

4. **MQ3**

Fig. 10 MQ3

This sensor is used to detect the presence of any harmful or toxic gases which could possibly contaminate the medicines.

D. Module 4: Inventory Management

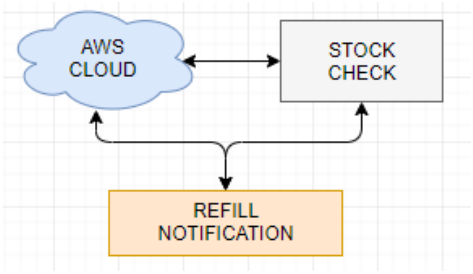

Fig. 11 Inventory Management

Using various inventory management software available on AWS the cloud database can perform frequent checks to ensure that the stock for each drug is maintained. If a shortage in supply is detected then a notification is sent to the supplier to provide a refill. Using software such as RestockPro and Sellics the database can detect certain red flags such as quicker depletion of inventory and higher volume of orders. [4] In such cases the system predicts a surge in consumption and assigns pre-orders to maintain steady supply.

VI. EXPERIMENTAL RESULTS

The result of the experiment done using Node MCU can be understood with the output and the graphical analysis.

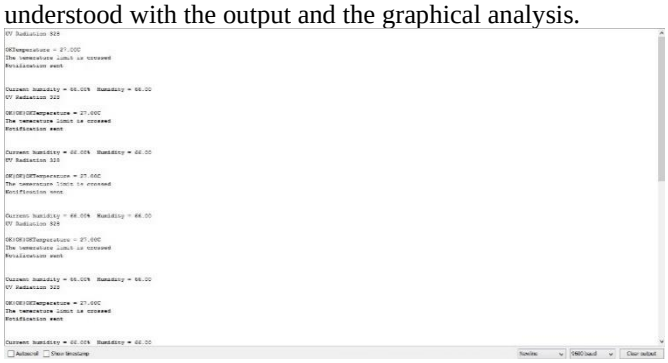

Fig. **12Output Recorded**

Arduino IDE is an integrated environment for hardware programming using C. It can be used to program Node MCU ESP8266. The parameter recordings are as shown in Fig 12 in the Arduino IDE at baud rate 9600.

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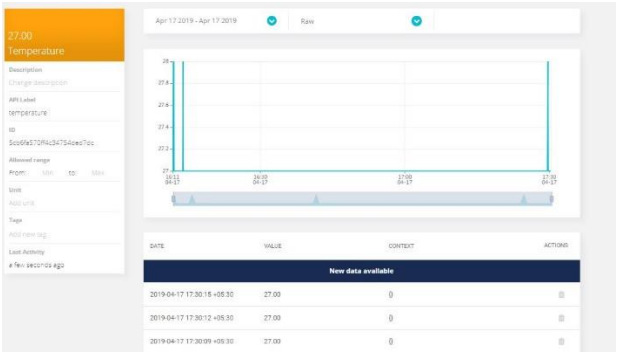

Fig. 13Graphical Output for Temperature Recordings

The graph in Fig 13 shows the temperature readings, noted at an interval of every 3 seconds, as long as the Node MCU is connected to the Internet. The notification will be sent once the temperature exceeds 25C for more than a minute. The temperature value can be altered according to the requirement of different medicines.

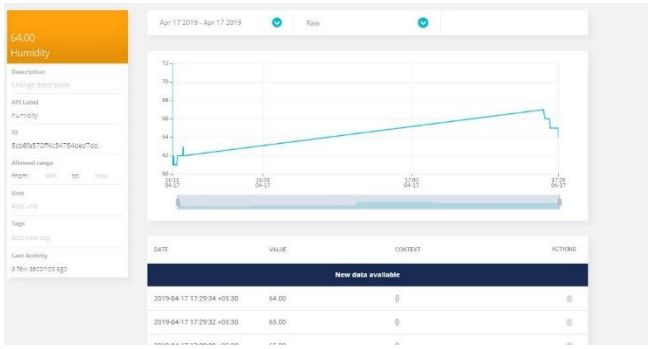

Fig. 14Graphical Output for Humidity Recordings

The graph in Fig 14 demonstrates the humidity readings, noted at an interval of 3 seconds whenever the Node MCU is connected to the Internet. The notification will be sent once the humidity exceeds 60% for more than a minute. The humidity value can be altered according to the requirement of different medicines.

Fig. 15 Graphical Output for UV Radiation Recordings

The graph in Fig 15 shows the UV radiation readings, recorded at an interval of 3 seconds whenever the Node MCU is connected to the Internet. The notification will be sent once the UV Radiation exceed the given limit for more than a minute. The values at which the notification is sent can be altered according to the requirement of different medicines. Also, we can actuate events automatically to control these values.

VII. FUTURE ENHANCEMENTS

The data from this system can be used to predict a spread of any disease, study consumption patterns within a region, etc. This device can be used to track the medical history of a patient and can also help in avoiding antibiotic resistance.
All of this can be achieved by performing machine learning on the collected data. Using voice assistants and buttons in braillein our pharmaceutical dispensers making it user friendly for blind people.

VIII. CONCLUSION

The proposed system an automated distribution system which uses embedded system and cloud computing to work like an ATM. The consumers are provided with a special prescription that they can insert in the machine. The machine verifies with database if the requested drug is in stock. The machine accesses its cloud storage to check the database using Amazon S3 (Simple Storage Service) or RDS (Relational Database Service). If the drug is in stock, the machine fetches the cost and furnishes the user with the payment options. The whole purpose of this machine is to ensure that medical care and emergency medication is available to all people, anywhere and at any time. The user friendly nature of this device aims to change the way people buy drugs and help promote a more efficient and faster means of distribution that causes fewer errors and can enable any patient, doctor or hospital to keep a detailed account of consumption and make it easier to obtain . This data has also proved to be useful to organizations that study patterns in spreading diseases.

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