Smart Cash Service and Operational Cost Reduction for ATMs in Smart Cities using IoT

Karanam Uday Kiran, Sarath T V

Abstract: ***Automatic Teller Machine (ATM) is one widely preferred choice for cash withdrawal for consumers. Getting an ATM with required amount and denomination has always proved to be a hurdle for consumers in search of cash. One way to counter this is to install more number of ATMs in locality to ensure the customer's requirement are met. However this proves to be an overhead for bank utility in terms of maintenance and operation cost. When the number of ATMs increased its difficult for consumer to know in which ATM the cash is available so to overcome this problem by this work we put forward an architecture that uses the concept of IoT in order to help the user find the nearest ATM with desired amount and denomination and reduce the operation cost of the ATM for bank utilities by actuating the electrical appliances with the help of microcontroller and sensors. By the concepts of IoT and wireless sensor network the work is done for easy cash search service where the user can know about the availability of cash in the respective ATM with the preferred denomination. Even though there many ATMs in the cities power consumption is the problem to overlook for the bank utilities so by this smart automation the operational cost of the ATM is decreased which is helpful for the bank utilities***.

Keywords: Internet of Things, Mqtt, Publish-subscribe, Smart ATMs, ATM Automation, smart cash service, operation cost reduction.

I. INTRODUCTION

Money is an important part of our day to day life and the need for it may arise at any point of time. Automatic teller machine (ATM) is a system which is used for various purposes like accessing a bank account, retrieval of money and transferring of money. An ATM is one of the best option for a common man to retrieve cash from their accounts. In the present world there are a large number of ATMs deployed across each city by the respective banks so as to meet the needs of the consumers. ATMs provides easy method for cash withdrawal, any other transactions during any time of day or night for the consumers. Of all the advantages of existing machines, there are many issues that arise regularly concerning the ATMs. Even the already large number of ATMs sometimes fails to satisfy the consumer needs, either due to lack of money in ATMs or desired denominations.

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Customers have always found it difficult in finding nearest ATMs with cash and proper denominations. Thus finding a nearest ATMs with the required amount and desired denominations is an interesting challenge that hasn't been addressed till now. From the perspective of bank utilities, an increase in number of ATMs implies more maintenance and operational cost for the utilities. Majority of the cost incurred by bank goes into meeting the operational cost. The ATMs are operational all around the clock for whole year. The lighting and air conditioning appliances inside the ATMs are operated even in cases when it is not required. This causes a lot of power wastage as well as unnecessary cost for utility. There are few existing works done on ATM services and the attacks on them that are analyzed for monitoring and alarming the calls and SMS for security alerts. In [1], S. Sriram talks about the security issues related to an ATM regarding theft detection. In [11] Narmada talks about the security issues during the transactions in ATM. A smart ATM node is developed in [15] using a pin camera connected to the node where it captures the images of the person, therefore if any theft happens in the ATM it sends the captured image to the respective bank. In [16] MerilThanga Roy tells about the issues in ATM that are increased day by day so it very important to challenge and face the issues regarding the ATM services. Any of the users where facing problems about the ATM related services because whenever cash is needed ATM is the option to withdraw the money but there are many issues like breakdown, out of cash and network failure etc., customers where fear of this ATM technology because of this issues which are raised by the people. ATM is one of the used machine for the cash so in this [10] describes about the ATM surveillance system that whenever supply is gone in ATM it sends the message to the bank user. In [20] GaddamSarathdiscuss about the various security and safety issues in the industrial Internet of things regarding safety aspects for generating a warning signal to avoid any underground mining using IoT and cloud server for optimizing safety in the mining industries. In [19] Somnath Paul tells that the server gets heated up and the system might be crashes or it might decrease its life spam so by using IoT concepts where the system hazard is done by monitoring the system. Smart wireless network is developed in [2] using a launch pad where the sensor detects the motion and is integrated to the Launchpad where the sensor detects the presence of any intruders and sends message to the

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Owner about the presence of obstacles and turns the alarm for security alerts.Li et al. discussed about the communication used to develop a communication platform between different types of components [13]. [14] Developed by hardware platform for many microcontroller to access various sensors and to control the stepper motor. Serial communication is used for communication 51 microprocessor unit and transceiver. According to the some wireless communication the specification to improve the routing through the protocol stack. In [3] the paper tells that the application is developed from the system which can be extended as a home automation system where the owner can control the electrical appliances like fans and lights remotely. Wireless communication technology for WSN is explained in [4] where wireless technology equipment's are connected to a wireless communication using the simulator for parameters such as transmission time, data coding efficiency and energy consumption. The results show that the transmission time of wireless components which is longer than few wireless equipment's and the data coding efficiency is much larger. The power consumption for the wireless sensors is based board is also less than few wireless communications. Various technologies used in wireless sensor networks [5] are explained in two basic categories for WSN's, among them star based network with single hop connectivity to a sink is explained which comprises the multihop connectivity that needs more sophisticated design. In [7] R. Kodalisummarises the approaches that uses mobility in WSN's and also introduces a new approach to compute trajectories in mobile platforms. Approaches that exploit the mobility in WSN's can be divided into three categories depending upon sink categories. In [12] the mobile base station solutions, during operation time the sink changes its position, in mobile data collector based solutions the source sensor stores the data until the sink visits it and receives the data and in rendezvous based solutions the data is sent to an assigned point where it is stored until the sink which is mobile comes and receives it. A method to develop a communication platform that enables interoperability between elements of various types, regardless of their software platform and manufacturer is described in [8]. Platform independence is guaranteed by developing a message architecture in node and is deployed on node. In [17] Andrea Zanella tells that smart cities are designs to support the administration of the cites and for the citizens. This technology, protocol and architecture for an urban IoT and the guidelines adopted by the smart cities where the sensor detects the temperature and humidity so that depending on the environmental condition and by using a protocol it sends the humidity and temperature value to the IoT platform and alerts the city from the earthquakes and any natural disasters. In [18] MajisAlKuwari tells about the controlling of electrical appliances by microcontroller and sends the data to cloud and according to its threshold value cloud actuates the electrical appliances by retransmitting the regulated value to the microcontroller. [6] Discuss about some secure group of communication in a node were the data is communicated wirelessly inside the node. An air conditioning system that uses a fuzzy control system for energy conservation is explained in [9]. A database is created where the temperature and humidity values collected using the sensors are stored. The fuzzy control system compares this data with the data set by the user. This is used to calculate the operating speed of fans and air conditioning system. Thus the temperature and humidity values of the air conditioning system are kept under the values set by the user using fuzzy logic. The rapid boom in field of IoT has paved way into improving the services offered to customers in all corners of life. In this work we put forward an architecture that would improve the profit for the bank utilities by reducing the operational cost of an ATM and also provide an easy cash search service for customers which can help them find nearest ATMs with required amount and desired denominations. Recent advancements in the field of IoT and cloud computations have offered a newer approach in making the ATM's more customer friendly

II. SYSTEM OVERVIEW

The proposed system architecture consists on a ATM node, a kiosk and a database hosted in a server as shown in figure 1. The kiosk is a static machine which is deployed across smart cities which provides the consumers to query regarding availability of cash in desired denominations within the vicinity of the consumer. The server upon receiving the query from a kiosk runs an algorithm to find the nearest ATM with required cash and denomination as requested by the user. The details of the bank such as location, current amount balance and available denominations are updated in a database that is hosted in the server. The ATM specific details are communicated to the server from the ATM by nodes deployed in the ATM. The ATM nodes perform the functions of updating the server regarding details cash and denominations as well as it helps in sensing the environment inside the ATM. Each of the node is consisting of sensors and actuators that help in reducing the operational cost for the utilities. The algorithm for reduction of operational cost is deployed on the server which acts upon the inputs from the ATM nodes.

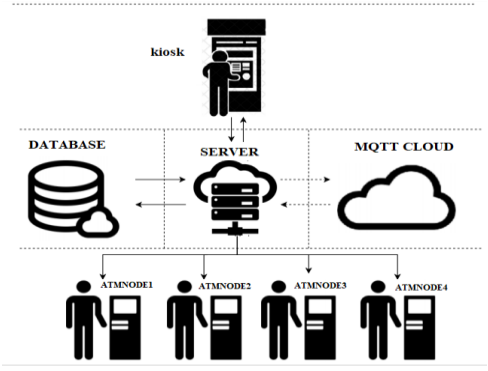

Figure 1 System Architecture

A consumer can make a query regarding their desired amount and denomination via a kiosk which requests the server to find the nearest ATM with the requested amount.

The algorithm that runs on the server checks the ATMs which have the sufficient amount as well as required denominations and calculates the shortest distance between available ATMs and respond back with location of the nearest ATM that meets the requested conditions. In case none of the ATM in the vicinity of the kiosk has sufficient balance or denomination, server respond back with appropriate intimation. The ATM nodes are equipped with sensors to sense the environment inside the ATM room and send the sensed data to the sever which takes the decision on reducing the power consumption of loads based on the occupancy of the room. In the absence of human in the ATM room, the loads are controlled by transmitting control message from the server to the ATM node which has appropriate actuators to control the loads.The mode of communication between ATM nodes and server is wireless medium which inherently is highly susceptible to noise and since the data transmission is frequent, it requires an efficient IoT protocol to be implemented for this communication. Mqtt protocol was chosen as the IoT protocol for communication between ATM nodes and the server since the message overhead and network latency can be reduced by the use of Mqtt. Another communication link in the proposed architecture is between kiosk and server which has lesser data transmission compared ATM nodes. The data that gets communicated between the nodes in this link is the query from the user and its response from the server.One of the functionality of the ATM node is the automation of the ATM room in accordance with the algorithm for operational cost reduction. It consists of a microcontroller interfaced with sensors and actuators as illustrated in figure 2. The sensed data is transmitted to server by a wireless modem connected to the microcontroller. Upon receiving the control message from the server, the ATM node actuates the load connected to it which help in reducing the power consumed thereby decrease the operational cost.

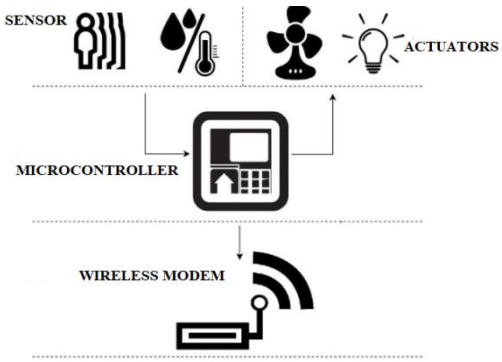

Figure 2 ATM node

III. IMPLEMENTATION

The ATM nodes and kiosk node was developed using NodeMCU microcontroller as it is a low cost and open source IoT platform. The sensors for sensing the environment of the ATM room for occupancy and temperature variations were selected as PIR and DHT11. The service for reducing the operation cost of ATM for utility is done by intelligently controlling the appliances inside the ATM room based on sensor node data. The sensed data is transmitted wirelessly to the server. Since the environment has to be frequently sensed to observe all the changes inside the ATM room, the data transmission frequency also will be high. This brings complexity in selection of communication protocol between ATM nodes and server. Mqtt is a lightweight messaging protocol following a publish subscribe model. Mqtt chosen as the IoT protocol for all the advantages it provides in terms communication overhead and latency. Cloud MQTT is the broker used for MQTT communication between server and ATM node. ATM node publishes ambient temperature and PIR data under topics Temperature and occupancy to the server. Raspberry pi is used as sever for this system architecture which subscribes the temperature and occupancy topics. Based on the threshold value set at the server, a control message is published by the server under the topic name actuation, which the ATM nodes are subscribed to. Depending upon the control message in the topic the ATM nodes actuate the relay for controlling the lighting or regulate the fan/AC inside the ATM room. Figure 3 shows hardware implementation of an ATM node based on NodeMCU microcontroller which has inbuilt Wi-Fi modem. PIR and DHT11 sensors are interfaced with the microcontroller to sense the ambient conditions. Upon reception of control message published by the server the microcontroller actuates the lighting load using relay and regulate the speed of motor to maintain the temperature in the ATM room.

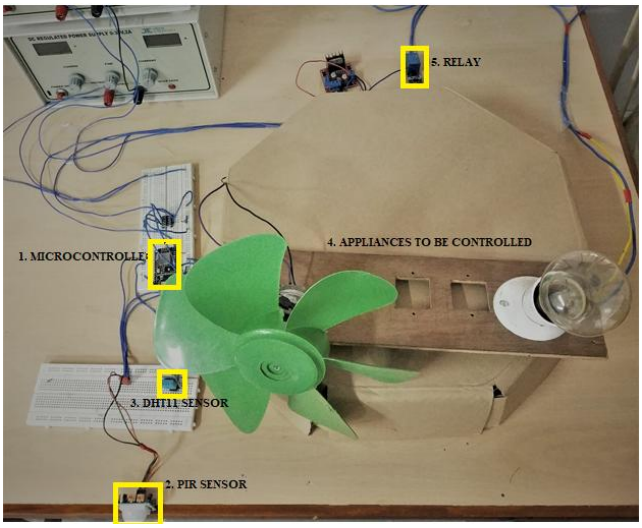

Figure 3 Hardware implementation of ATM node

The kiosk based system is implemented using NodeMCU with the provision for user to make query through a serial monitor interface. The customer can select details like preferred bank, amount and desired denominations from the serial interface.

This request gets forwarded to the server where an algorithm is deployed to find the nearest ATM which meets all the requested conditions of the customer. Figure 4 illustrates the flow chart of the algorithm. The algorithm begins once the data from the kiosk is received by the server. The algorithm works under one assumption that the server keeps a database of all the bank ATMs in its vicinity. The database keeps details like location, amount in the ATM and denominations in each ATM and these details are updated by the ATM nodes periodically. The algorithm checks if the requested amount and denomination is available in the preferred bank ATM. If it has, server responds back with details of the location of the bank to the kiosk where it gets displayed. In case the preferred bank ATM doesn't have requested amount or denomination, the algorithm searched the database to see if any other ATM in the vicinity has requested amount and denominations and after filtering, calculates the distance between all the ATMs and the kiosk. Then the ATM details with shortest distance is suggested to customer. In case none of the ATM in the vicinity has the requested amount, that information is passed to the customer.

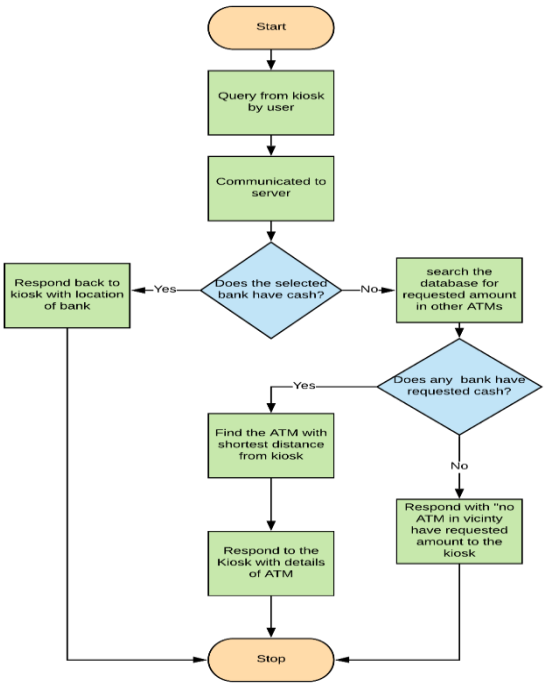

Figure 4. Flow chart of cash search algorithm

The overall flow chart is about the algorithm used to find the availability of cash in the ATM by the following steps:

Step-1 Query asked by the user from the kiosk about the availability of cash in the respective ATM. Step-2 Kiosk communicates with the server about the query asked by the user.Step-3 server checks with the Database if the selected bank has the amount it responds back the kiosk about the availability of cash with the location.

Step-4 if the selected bank doesn't have the amount it checks with the other bank in Database if other bank has the required amount it responds back to the kiosk about the respective bank with nearest location to the consumer.

Step-5 if the required amount is not there in any of the bank which is connected to the server it responds back to the kiosk that no ATM in the vicinity has the cash.

IV. RESULTS

Easy cash search service that allows the user to query for nearest ATM with desired amount and demonization is implemented with kiosk as the front end for the customers to input their choices. The kiosk like system interface was developed using serial interface of NODEMCU microcontroller. Figure 5 shows the interface for entering the choice for customers. The user can choose their preferred bank, the amount and choice of denomination.

```
Hi!
 Select and Enter the bank name
1.SBI
2.Dhanlaxmi
3.Laxmivilas
4.Axis
5.IDBI

LAXMIVILAS
Enter the amount required :

pm open,type:2 0
25000
 Do you have denomination preference ?

yes
 Enter the denominations u need :
 ***Example: 100 or 100,500***/n
100,500,2000
```

Figure 5 kiosk query interface

Based on the query made by the user, NodeMCU publishes the data to the broker and the algorithm implemented in the server finds out the nearest ATM with desired amount and denomination. Then the details of the bank ATM is published to the kiosk node by the server and gets displayed in the kiosk. Figure 6 illustrates such a response from the server for a query made in figure 5.

```
There is enough money
Nearest bank is LAXMIVILAS BANK at CHAVADI
```

Figure 6 Response from server to the user query

Reducing the operational cost of ATMs is done by controlling the lighting load and maintaining ambient temperature depending on the occupancy of the ATM room. ATM node published the information regarding temperature, humidity and occupancy status to the server as shown in figure 7.

```
60.00Temperature =
31.00Message arrived [result/person] 0
received in person
0
Humidity =
60.00Temperature =
31.00Message arrived [result/temp] 255
received in temp
255
Humidity =
59.00Temperature =
31.00Message arrived [result/person] 1
received in person
```

Figure 7 Mqtt Message published by ATM node

The server based on a threshold decides the control message to be published to the ATM node. Upon reception of the control message from server the ATM node actuates the loads as per the received message. For controlling the ambient temperature PWM control is used. The message published from the server for temperature control gives out how much PWM should be used for the device. Figure 8 exemplifies how the Mqtt message from server is published as well as how the temperature and humidity data are received.

```
('message received ', '31')
('message topic=', u'temp')
('message received ', '1')
('message topic=', u'person')
published to result/person = 1
('message received ', '31')
('message topic=', u'temp')
('message received ', '0')
('message topic=', u'person')
published to result/person = 0
('message received ', '31')
('message topic=', u'temp')
('message received ', '0')
```

Figure 8 Mqtt received and published at server.

V. CONCLUSION:

Cash search has always been a great issue for consumers in the case of ATM and the bank utilities in order improve the experience of customer's increases the number of ATM in the cities which incur them huge amount in maintenance and electricity bill. In this work, we propose an architecture that brings out benefit for the customers as well as utilities at the same time. A system consisting of sensor nodes and front end for the user was developed for providing an easy cash service and reducing operational cost of the ATM. An intelligent embedded server was developed to maintain this network using raspberry pi which took care of the algorithm for easy cash service and maintain operation cost within limits. Reducing of operational cost in the ATMs with the smart automation can save the power consumption by the electrical appliances. The Mqtt protocol used for communication between all the nodes in the network ensured the communication overhead and latency is kept minimum.The implementation and propose work is economical for both consumers and bank utilities.

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