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Li-Fi, IoT Enabled Purchase System with Auto Product Detection and Android Payment- An Effort to make Billing Queue Obsolete

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Abstract*—RFID and Barcode technologies are the ones that are used widely in shopping for the purpose of maintaining an inventory including billing. But this technology causes long queues for billing while purchasing. Our project focuses on using the visible light communication method of communication called the Li-Fi technology. Light Fidelity (Li-Fi) is a bidirectional, high speed and fully networked wireless communication technology similar to Wi-Fi. Using LED lights for both illumination and communication will make shopping and our lives easier and it is eco-friendly. For the purpose of Green World we employ Li-Fi technology to detect the products, keep track of the products at the store, and aid in eliminating billing queues by auto billing using android app. Android application is deployed on the consumer phone which is attached with Li-Fi Hardware via OTG. Every product and trolley is attached with Li-Fi Module. User on dropping the product into the trolley, the product details will appear on the screen and its cost is added in the Android app and finally total payment is made by the user via android based payment system. Details are transferred to the shop server. Shop Server will communicate with the Gate section of the shop. Gate's Li-Fi will communicate with the Li-Fi which is attached with the Trolley for product verification. Finally only billed products are delivered.

***Index Terms*—Light Fidelity (Li-Fi), Liquid Crystal Display (LCD), PIC16F877A Microcontroller, Radio Frequency Identification (RFID), Wireless Fidelity (Wi-Fi).**

I. INTRODUCTION

Barcode technology and the use RFID in shopping malls made the shopping easier and convenient at the time. But at the recent times, the number of customers and the quantity of items bought has been increased tremendously. This has caused long queues waiting for billing. A survey made by Visa in 2005 [11], shows that, 70% of the customers waiting in long queues walk out and 10% of the customers get seriously annoyed. CISCO Internet Business Solution Group [12], estimated the top 4 reasons for shoppers to use technology are 1. Find best price (63%) 2. Save time (47%) 3. Find best assortment (26%) 4. Best quality (25%). All of these reasons for which customers are seeking technology needs a proper solution. Li-Fi technology is used by our project to solve the customers' need for seeking technology in shopping. It can be employed in huge malls to any mini-store where the number of shoppers are more. This provides a means for shoppers to easily compare prices, save shopping time, find best assortments and bill automatically. Also the present method involves manual billing. Using barcode readers for billing causes long queues. And each product is checked and entered at the billing section. Estimating the overall price of the picked products is hard and getting the products' information is difficult and time consuming. The other factor is that, in the presently used technology, radio frequency is used. Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth. It is safe for humans since light, unlike radio frequencies cannot penetrate human body. Hence, concerns of cell mutation are mitigated. Our project paves way for a better world as it employs Green Computing by using visible light communication methods at shopping malls, complexes, and other stores to enable people to experience an easy shopping way to reduce their time. And useful for shopkeepers in keeping track of products and reduce their efforts. It's a win-win for both the shopkeepers and the shoppers. As our project uses visible light, unlike radio waves, it is safe on humans. The problems with the present technologies of using RFID and Barcode readers has the problems of long queues, customer cannot easily make a budget-fit shopping, uses radio frequency, manual billing. Our project solves all these problems. This automatic way of detecting product and online payment took away the queues. Customers can easily make budget-fit shopping as the subtotal of the products in trolley is displayed. It has no radio frequency bandwidth allocation problem and it much safer. It doesn't require manual billing. And verifying the products purchased is made easy, without any manual checking. This makes shopping convenient and saves time. With the advancements in technologies, using the apt ones will make lives easier and world greener. Our project focuses on using a simple

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LED way of communication called Li-Fi technology. This way, lights can be installed in the stores for illumination (as always) and also use it as a means of communication.

II. PROPOSED MODEL

Our project focuses on using the visible light communication method of data transmission called the Li-Fi technology. Light Fidelity *(*Li-Fi*)* is a bidirectional, high speed and fully networked wireless communication technology similar to Wi-Fi. Li-Fi technology is used in our project to solve the customers' need for seeking technology in shopping. It can be employed in huge malls to any mini-store where the number of shoppers are more. This provides a means for shoppers to easily compare prices, save shopping time, find best assortments and bill automatically. Also the present method involves manual billing and maintaining inventory is hard. Using of Li-Fi helps in tracking the products easily. Also billing can be made automatically over net banking. Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth. It is safe for humans since light, unlike radio frequencies cannot penetrate human body. Hence, concerns of cell mutation are mitigated.

The proposed plan of action for our project is to establish an optical wireless communication model that gives high data rates (in the order of MHz) and transmission distances of up to 1m. This model should effectively be able to transmit data from one device to other using LEDs, thereby establishing a Li-Fi network in a localized environment.

The system architecture consists of a transmit section and a receive section. The transmit section consists of the data input which is then fed into a switching control system. Based on the data, the switching control generates a stream of 1s and 0s thereby encoding the data in binary. The output of this control is given to the array of LEDs which turn OFF and ON at extremely high speeds. This ON-OFF modulation of the LED light transmits the data. LED is the choice for light source since it consumes very less power when compared to fluorescent lamp or a light bulb. It consumes about one-tenth the power when compared to conventional methods of lighting. Also, the lifetime of a typical LED bulb is several tens of thousands of hours. LEDs are also fast switching with good visibility.

Thus, LEDs are ideal for use as the downlink transmitter. For the uplink transmitters, Infrared (IR) can be chosen to be the uplink transmitter for user convenience. This avoids fitting an LED light source on or next to the mobile devices. The receive section consists of a photodiode, e.g. silicon photo detector or an infrared germanium cylindrical detector. The photo detector demodulates the incoming received signal based on the sequence of 1s and 0s. The demodulated signal is then sent to a filter to remove unwanted noise. This filtered signal is then amplified using signal amplification mechanism. The filtered and amplified signal is then given to an output device such as an LCD display or a speaker. The input signal is thus remotely transmitted and received. Thus, a Li-Fi network is established.

III. ADVANTAGES OF PROPOSED SYSTEM

1) Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses visible light spectrum that has still not been greatly utilized.

2) High data transmission rates of up to 10Gbps can be achieved.

3) Since light cannot penetrate walls, it provides privacy and security that Wi-Fi cannot.

4) Li-Fi has low implementation and maintenance costs.

5) It is safe for humans since light, unlike radio frequencies cannot penetrate human body. Hence, concerns of cell mutation are mitigated.

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IV. SYSTEM ARCHITECTURE

Fig. 1 System Architecture

Android application is deployed on the consumer phone which is attached with Li-Fi Hardware via OTG. Every product and trolley is attached with Li-Fi Module. User on dropping the product into the trolley, the product details will appear on the screen and its cost is added in the Android app and finally total payment is made by the user via android based payment system. Details are transferred to the shop server. Shop Server will communicate with the Gate section of the shop. Gate's Li-Fi will communicate with the Li-Fi which is attached with the Trolley for product verification. Finally only billed products are delivered as shown in figure 1.

V. MOBILE CLIENT

Mobile client is an android application which is created and installed in the user's android mobile phone. For creating an application, we used advanced java concepts like JSP and Servlets. The user has to enter the ip address. Once entered, they are allowed for purchase of the products which includes product detection and payment. As for the embedded components, mobile is connected to a Li-Fi transceiver through an OTG cable as shown in figure 2. This Li-Fi module is used to read the product information.

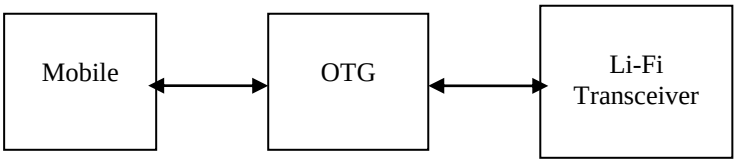

Fig. 2 Mobile Client

OTG acts as an interface between the mobile and the Li-Fi Transceiver. The Li-Fi module connected to the mobile is in sync with the shop server. The Li-Fi attached to the product and the Li-Fi attached to the mobile transfers data. This is used in detecting the product information and the receiver information is display on the application in the mobile. The information that is required to be display can be programmed as per the shop owner's wish. In our project we display the product name and the price of the product. If required the expiry date, any available offers or any information that is required to be display can be programmed and fed into the database and made to display. The mobile can be substituted with the tablet or any other device that can run an android application. This module hence adds up to the detection of products and display of the details on the mobile application. The payment can be then made through net banking. Also the application transfers the purchase details to the shop server.

VI. SHOP SERVER

Server is used to verify the product information and allow the user to purchase. Product information will be stored in shop server. Also the server will analyse the purchase details of the user. So that we the server will extract the identity. The server module will maintain the entire user access information and respond to the client's request. Since the communication between the user and the server is frequent, we have to establish a communication between them. For this purpose we provided network connectivity between them. All the products are connected to Li-Fi module. The data stored is maintained by the shop server.

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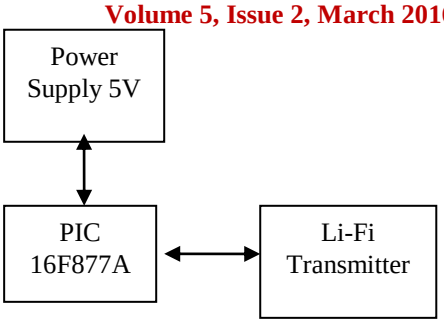

Fig. 3 Product Server

PIC16F877A is used as CPU machine as shown in figure 3. It only has 35 simple word instructions. Since the data to be processed is less, it is convenient and a cheap option to use. Power supply is given to it and a Li-Fi transmitter is attached to it. This makes up a product module. All the information that these products carry are stored in the shop server. Shop server acts as the main database for all the product details. Shop server is also responsible in collecting the purchase information of every shopper. It stores the information and also sends the list of purchased products to the gate section.

VII. LI-FI HARDWARE SETUP

There is a light emitter on one end, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off.

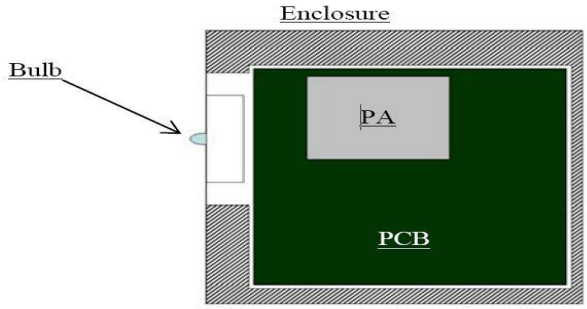

Fig. 4 Block Diagram of Li-Fi Sub-assemblies

To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The LEDs can be used as a sender or source, by modulating the LED light with the data signal. The LED output appears constant to the human eye by virtue of the fast flickering rate of the LED. Communication rate greater than 100 Mbps is possible by using high speed LEDs with the help of various multiplexing techniques. VLC data rate can be increased by parallel data transmission using an array of LEDs where each LED transmits a different data stream. The Li-Fi emitter system consists of 4 primary subassemblies a) Bulb b) RF power amplifier circuit (PA) c) Printed circuit board (PCB) d) Enclosure as shown in figure 4. The PCB controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. A RF (radio-frequency) signal is generated by the solid-state PA and is guided into an electric field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb‘s center; this controlled plasma generates an intense source of light.

VIII. BANK SERVER AND GATE SECTION

After purchasing the products, user can pay the bill in android application. The amount is debited from the customer account. This information is automatically sent to the shop server. A simulated bank server is made for the purpose of payment. Gate Li-Fi receives the information from the shop server and verify with the products in the trolley. This will help in detecting unbilled products, if any. The hardware requires power supply of 5V, LCD (Liquid Crystal Display) screen as shown in figure 5.

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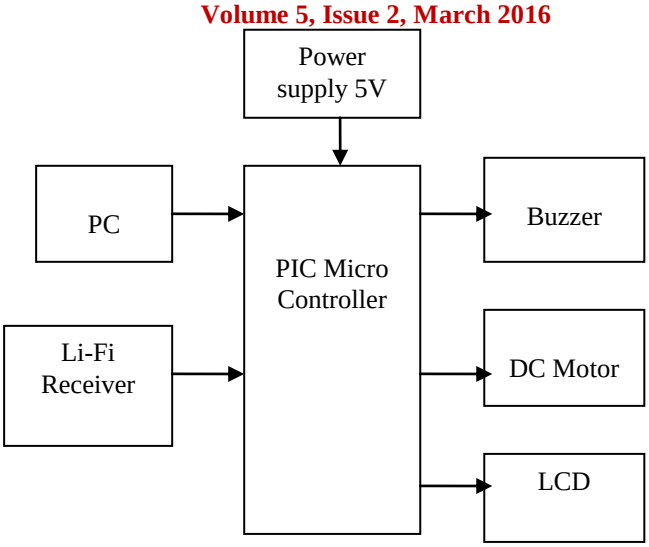

Fig. 5 Gate section

IX. RESULTS

Our project narrows down to the fact that the retailers and the shoppers are going to save a lot of time and find the convenience of using Li-Fi technology in shopping is a win-win for both the retailers and the shoppers. The result is that the billing queues formed at shopping malls and stores are made obsolete. When there is any product that is not purchased is in the cart, the gate section makes a buzz sound to alert the shopper and the shop. It is an effort to make sure that the shopper has not missed any product after purchase. and to alert the shopkeepers, in the case of stealing. Taking a scenario, the user has one product in the trolley as shown in the figure 6.

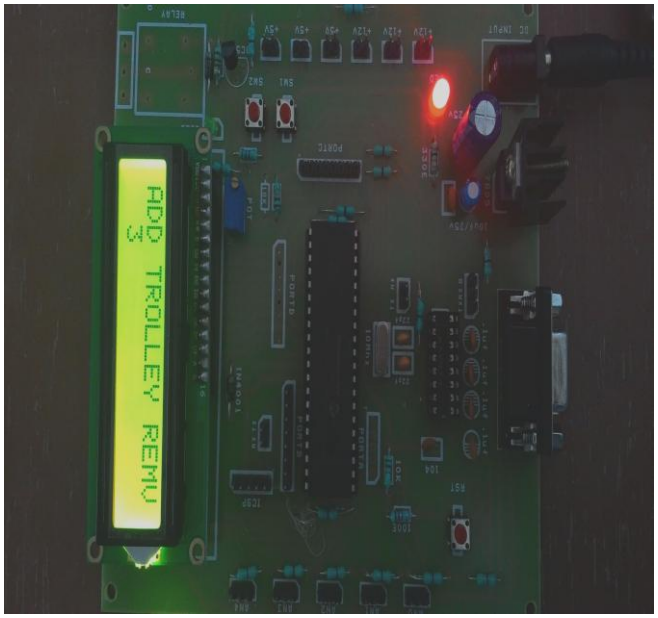

Fig. 6 Trolley Li-Fi Module

The shopper has made purchase for three products and this information is sent to the gate for verification as shown in figure 7. There is a mismatch which causes the buzzer to sound. The shopper can hence know that products are missing in the cart and the shopkeepers can help the shopper.

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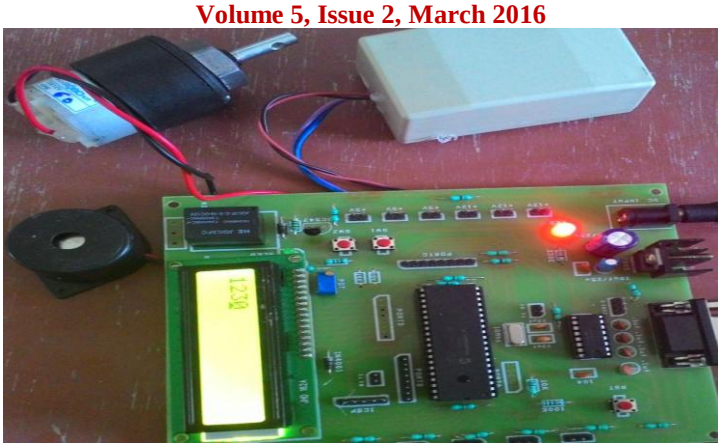

Fig. 7 Gate Li-Fi module

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