Implementation of Toll Collection System using LI-FI

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Abstract- The existing radio-wave spectrum is insufficient to match the need for speedier communication as technology advances and the number of users increases in today's globe. A newly emerging technology called Li-Fi is combined with a toll collection system to address challenges like availability and security. In comparison to Wi-Fi, Li-Fi covers a wider range of frequencies and wavelengths, from infrared to visible to ultraviolet.In India, a variety of toll collecting methods have been adopted, including manual toll collection, RFID - FASTag, and number plate recognition. Each of these systems has its own set of disadvantages, which can be mitigated to some extent using LIFI technology. This concept depicts a toll booth that runs entirely on LIFI technology. Unlike other radio-based toll systems, this system will not only combine an emerging technology with a well-known application, presenting a novel approach, but will also suggest answers to problems encountered by existing technologies.

Keywords —led, light fidelity, radio frequency (RF) , RFID Tag, visible light communication (VLC), toll.

I. INTRODUCTION

A high-speed wireless communication technology that uses visible light to transmit information is Li-Fi. Unlike Wi-Fi, Li-Fi uses visible light communication (VLC) or near-UV spectrum waves and infrared. The light emitted by the bulb can be used as a source for Li-Fi technology. So, any bulb (light source) can emit Li-Fi. If the LED source is given to the Li-Fi technology, then high-speed data communication is achieved. Instead of using Wi-Fi and other technology, Li-Fi increases the bandwidth by 100 times. Because the light spectrum is 10000 times greater than the radio waves. It can also be used in electromagnetic-sensitive areas like hospitals, airplane cabins, and nuclear power plants (where electromagnetic disturbance can be disastrous)[1]. Li-Fi is a wireless communication technology that, unlike Wi-Fi, employs light as a carrier signal rather than radio frequency. As we all know, light is a crucial part of our lives and flows at a far quicker rate than data. Li-Fi technology communicates via the Visible Light Communication (VLC) spectrum and has no adverse effects. Furthermore, Li-Fi allows users to access the Internet wirelessly in places where Wi-Fi is prohibited owing to interference or security concerns. With the ever-increasing demands of the telecommunications business, there is a greater push for more bandwidth that allows for faster and more secure data transfer while maintaining a cheap cost of implementation [2].

Wireless communication has become an essential part of our lives, and there are various sorts of technologies that are used for this form of communication, with Wi-Fi being one of the most used. It is a widely used device that affects our personal and professional lives. One of the applications is the Toll Collection System, which is becoming ineffective due to a wide range of uses of the Radio Frequency bands[3]. This is causing serious concerns such as capacity, efficiency, and security. Many research efforts have been made over the last few decades in the hopes of discovering an alternate solution to the RF spectrum overcrowding and maybe being replaced by a more efficient and effective technology. The many drawbacks of Wi-Fi can be easily mitigated by a new technology known as LIFI, which will successfully replace Wi-Fi in Toll Booths and can be efficiently utilized for various short-range communications [4].

There are large numbers of toll gates in the National Highways across the country. Most of the people find it very difficult to wait in a long queue because of the manually operating toll gate system. This causes waste of time and fuel. This project provides a great solution to all these problems. Most recently, Li-Fi is a new emerging technology in the trend[5]. Here, the concept of Li-Fi is used to eliminate this queue. As we use the concept of Li-Fi, high speed data transfer is achieved. So that the technology used in this project eliminates the queue in the toll gates and helps the people to reach their destination on time and automates the complete process.

II. EXISTING SYSTEM

Most of us are familiar with Wi-Fi (Wireless Fidelity), which uses 2.4-5GHz RF todeliver wireless Internet access to our

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homes, schools, offices and in public places. We have become quite dependent upon this nearly ubiquitous service. But like most technologies, it has its limitations. While Wi-Fi can cover an entire house, its bandwidth is typically limited to 50-100 megabits per second (Mbps) today using the IEEE802.11n standard. This is a good match to the speed of most current Internet services, but insufficient for moving large data files like HDTV movies, music libraries and video games.

The more we become dependent upon 'the cloud' or our own 'media servers' to store all of our files, including movies, music, pictures and games, the more we will want bandwidth and speed. Therefore RF-based technologies such as today's Wi-Fi are not the optimal way. In addition, Wi-Fi may not be the most efficient way to provide new desired capabilities such as precision indoor positioning and gesture recognition. Optical wireless technologies, sometimes called visible light communication (VLC), and more recently referred to as Li-Fi (Light Fidelity), on the other hand, offer an entirely new paradigm in wireless technologies in terms of communication speed, flexibility and usability.

A. MANUAL METHOD

Tolls are traditionally collected by stopping the automobile at the toll plaza, handing over the money to the toll collector, who then opens the gate either mechanically or electronically, allowing the driver to pass through [11].

Around 350 vehicles per hour pass via the manual toll collection lanes and this is one of the very commonly used toll collection techniques even up till now in various parts of the country.

B. FASTag

FASTag is a gadget that employs Radio Frequency Identification (RFID) technology to allow drivers to pay tolls while on the road. It's an RFID passive tag that's used to pay for tolls straight from the customer's account. It is mounted on the vehicle's windscreen and allows the customer to drive through toll booths with ease and without the worry of stopping the vehicle to manually pay the fare. The required toll amount is directly deducted from the account linked to the customer of that particular vehicle.

FASTag is also vehicle-specific, and it cannot be removed once it has been attached to a vehicle. There are numerous concerns with FASTag, such as it being scanned multiple times or the automated electronic deduction method failing if the server is down. It also is unclear whether a new owner will be able to drive the automobile with the same FASTag if the original owner sells the vehicle.

A single ETC lane can handle 1200 vehicles per hour.

III. PRINCIPLE OF LI-FI TECHNOLOGY

A Visible Light Communications (VLC) system is Li-Fi. It transmits data using visible light, which was devised by Prof. Harald Hass. The LiFi module is embedded in the LED bulbs through a tiny chip, allowing the terminal to connect to the network at any time. As long as the LED bulbs are turned on indoors, it communicates data by changing the frequency of their lighting. Its data transfer speed can exceed 10 Gb/s, breaking the WiFi transmission rate of 7 Gb/s. [4]

The potential application of this technology is actually pretty exciting. Wi-Fi bandwidths are becoming saturated, heavily regulated and they interfere with sensitive equipment. These are definite limitations for this great technology. The inevitable combination of the digital world with the principle of light manipulation to transmit information seems, for all intents and purposes, to be a natural evolution of wireless communications. Li-Fi certainly has the edge for frequent fliers and we can really see Light Fidelity kicking off in airliners, hospitals etc. It will be interesting to see future computer and smartphone design changes to take advantage of this technology.

A. ARCHITECTURE OF LiFi TECHNOLOGY

The digital streams data from the Internet will be fed to the lamp driver on the transmitter side, which is responsible for converting the data into a form of light signal. The data will be transmitted via an LED lamp.

A photodetector or photo sensor detects variations in LED light and converts light photons into an electrical signal on the receiver side. The data will be received by the receiver device after it has been processed, amplified, and converted back to its original format.

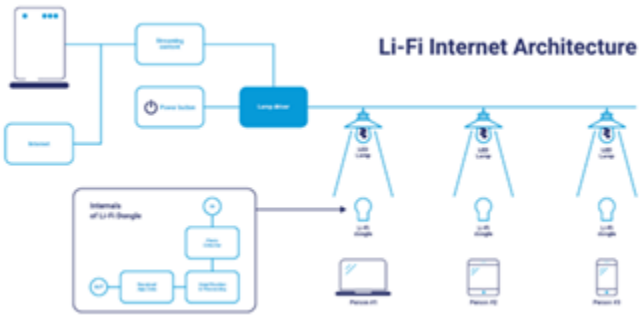

Fig.1

B. PROPOSED SYSTEM ARCHITECTURE

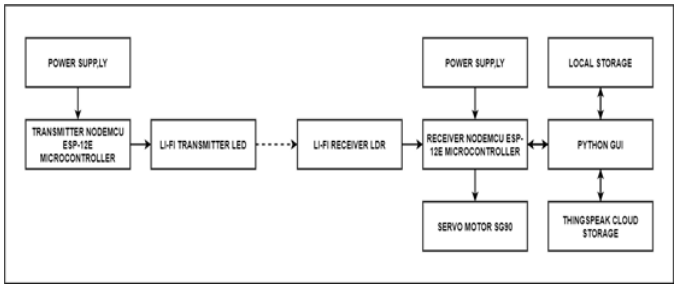

Fig.2

1. The toll collection system comprises a Li-Fi Transmitter which is connected to the Car and a Li-Fi receiver at the Toll. ESP32 Microcontroller is used in both transmitter and receiver.

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2. When the car arrives at the toll the Li-Fi Transmitter in the car will send a unique key to the Li-Fi receiver. The microcontrollers are programmed with embedded C.
3. This data is sent by the laser connected to the Transmitter Section. It is sent in the form of light signals. The LDR connected to the Li-Fi receiver receives this signal and decodes it into text.
4. The Li-Fi receiver then sends this text over COM Port to the GUI Software created with the Python Module. This key will be interpreted by the GUI Software, which will check for details.
5. If the car has a valid pass, the GUI Software will automatically instruct the Li-Fi receiver's microcontroller to open the servo motor-driven barrier gate. Invalid users will be requested to pay the fee in cash, following which the operator will manually send a command to the barrier, which will open it.
6. When a transaction is completed successfully, the user will receive an automated email from the same GUI Software.
7. The Yagmail Module is used to send the email. The Yagmail module includes a keyring that stores the user's email and password for automatic use.

IV. EXPERIMENTAL SETUP & GUI

A. *HARDWARE SETUP:*

Transmitter and Receiver both are connected to software via USB. Receiver's laser is switched on and it is directed towards the LDR on the transmitter. As the laser beam hits the LDR, data transfer takes place.

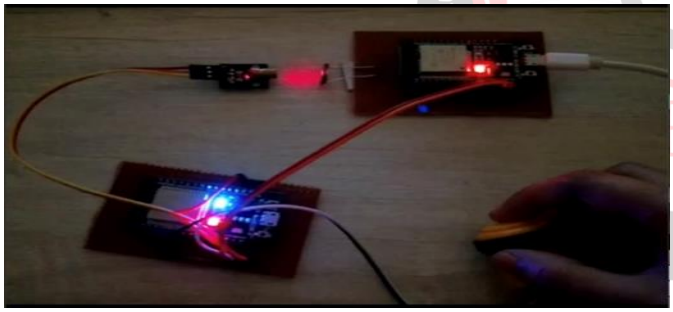

Fig.3

B. *GUI WINDOWS:*

Once the data is transferred, the GUI window opens up. The LIFI Toll Collection Utility page starts loading. The unique ID reserved for every vehicle is received by the GUI. Information about the user and the amount to be deducted is displayed.

Fig.4

Fig.5

V. RESULT

A. *Data Transfer*

1. The hardware is connected to the laptop.
2. After successful connection, data is transferred via LDR to the receiver.
3. Data is in the form of user Id which is pre registered.
4. When there is no transmission, NO DATA is displayed.

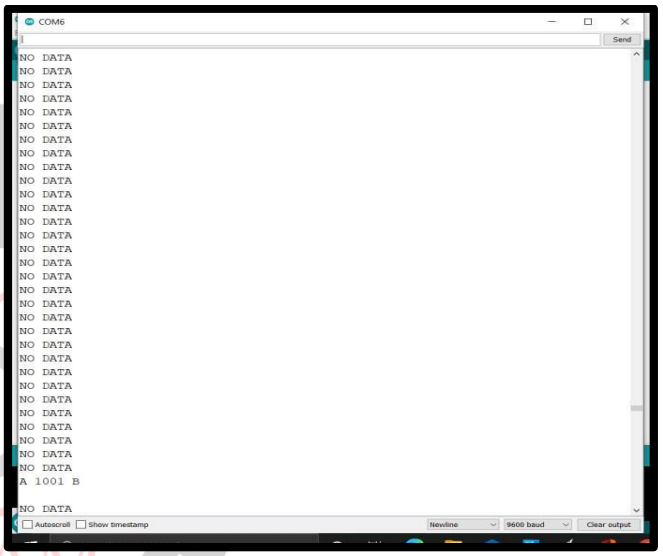

Fig.6 data being transferred

B. *Mail*

1. Mail is sent to the user after the transaction.
2. The mail displays details about the amount deducted.
3. Location & Time is also specified in the received mail.
4. Amount is deducted from the thingspeak software connected to the GUI.
5. Details about account balance are also provided to the user via mail.

Fig.7 mail sent to the user

VI. ADVANTAGES AND LIMITATIONS

ADVANTAGES:

A. *Increased Efficiency*

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Because lights are already used in workplaces and homes, and lifi is based on visible light technology, a similar source of light might be used to send data over the internet. Despite the fact that the light must be switched on to transmit data, setting the li-fi knobs such that the light is hardly visible to the naked eye is more realistic.

B. Cost

Instead of running a mile-long link, the LED-powered Li-Fi connection may be used to convey data straight to the target. Instead of the extra cables and links that are laid from one passage to the next, business venues can conveniently connect with one another utilizing a point-to-point array.

C. Security

The data transmitted by li-fi technology is only available to clients/users in a closed room and cannot be interfered with or detected by customers in other rooms or structures because visible light cannot pass through strong or opaque structures, Hence, the security that li-fi provides is one of the most important considerations.

LIMITATIONS:

A. Reliance on light sources

The light should be available 24 hours a day, whenever we need it, with Li-Fi. You can't turn off the light if you need continuous information transmission; you can only dim it.

B. Limited Range

Because visible light signals cannot enter/penetrate barriers, the range of Light Fidelity is quite limited. While this makes Li-Fi secure, some people may find the limited range to be a problem, which is caused by the receiver transmitting back to the transmitter.

The type of light source has a direct impact on the speed that a Li-Fi system can achieve by using big LED lights, mini-LED lights, laser LEDs, and so on.The mechanical system must be able to adjust to changing weather conditions if it is installed outside.

VII. CONCLUSION

In this realm of invention, there are a plethora of possible outcomes to be mined. Toll collecting will

be automated, saving time, effort, and people, and providing a significant advantage over traditional systems, such as manual toll collection. The concept of Li-Fi technology opens a lot of possibilities for future research and development. Because light is ubiquitous and free to use, the possibilities for Li-Fi technology utilization expand dramatically. Furthermore, powerful LEDs can be created to endure small interference from other light sources.

It will be more efficient to use Li-Fi technology in automatic toll payment. This concept not only saves users time, but it also reduces the amount of manual work that is currently being done. As a result, using Li-Fi will increase data transfer speed. The concept of Li-Fi technology is currently appealing to us, and it offers enormous potential for future research and innovation. Because light sources are easily accessible, the possibilities for using Li-Fi technology expand significantly.

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