

Advanced Home Automation using Light Fidelity

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Abstract— Light Fidelity or Li-Fi is an emerging technology that uses the visible light spectrum for communication. Home automation is one of the very useful ways to control various electronic devices used in a home for our day to day activities. This paper proposes the use of Li-Fi technology, comprising light-emitting diode (LED) bulbs, as means of connectivity. Data is sent through light spectrum on an optical wireless medium as signal propagation. This idea can be implemented as an android application connected to the cloud. All the devices in any home can be monitored and controlled using this app installed in a mobile phone. A user can change the state of any device (ON/OFF) with this app. Changes are made in the cloud, and a message is sent as a binary sequence to the hardware connected to the light source. After translation, the identity of the device that needs to be controlled is obtained along with the message to toggle it between the ON and OFF states. This message is sent across using visible light communication in a secure way as the data remains within the limits of the four walls. Hardware on the receiving end senses the blinking light source, and translates the blinks into a binary sequence thus obtaining the original message. Then the device performs the necessary action and updates the cloud after completion. This is further reflected on the android application of the user's phone. Attackers cannot break into this system easily, as the device identity and the light source is required to manipulate it.

Keywords— Li-Fi; VLC; Light Spectrum ; ESP 8266; Home Automation; Internet of Things (IOT); Wireless Data Communication; Cloud Database; Android.

I. INTRODUCTION

Wireless data rates have been growing exponentially in the past decade while the availability of the radio frequency spectrum remains limited. This gives a lot of scope to use Visible Light Communication (VLC) as a substitute to traditional Wi-Fi instead. Li-Fi provides a higher frequency bandwidth and immunity to noise and radiation as compared to the traditional Wi-Fi technology. Also with the advancement in technology, automating all the household amenities and appliances has become a reality. A smartphone can be used to control the home appliances. Thus by using the concept of Li-Fi and automation, a smart home can be created.

In recent years the amount of data to be handled has increased tremendously, along with concerns for security and transmission rate. Wi-Fi has been the traditional medium for transmission of data wirelessly. But the decrease in the bandwidth spectrum has limited its uses. On the contrary, Li-Fi

provides a larger bandwidth by replenishing more than 10,000 frequencies and all being free and unlicensed. The use of Li-Fi is better than Wi-Fi as it is immune to interference and does not interfere with other communication media. It is cheaper as it transmits data and provides lighting at the same time and requires lesser equipment for its functioning. There are no safety and health hazards yet known of this technology. It provides better security as the light used as signals for transmission doesn't pass through walls and is difficult to hack into the system [1].

As far as security is concerned, the light signals sent by the LED stay within the boundaries of the four walls. The signals are a combined stream of data pertaining to what the user wants to do with a specific device and a device identity that ensure only the desired device perform the actions mentioned. This technology can be used for communication in aircrafts where radio wave communication cannot be used as it would interfere with the devices on the aircraft used for communication and navigation of the aircraft's. Li-Fi can be used under water where radio waves don't travel a long distance due to the medium used for transmission.

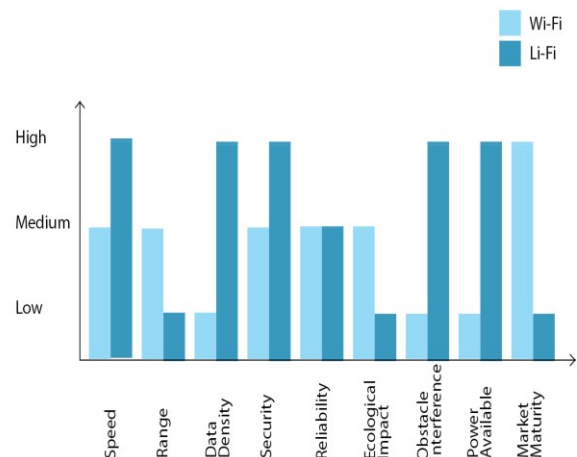


Fig.1 Comparison between Li-Fi and Wi-Fi

As mentioned in Fig.1, the achievable speed of Li-Fi is more than that of Wi-Fi at 3Gbps minimum and a maximum of 224Gbps. Li-Fi has a shorter range as the light signals do not penetrate walls whereas the radio waves of Wi-Fi do. Li-Fi can handle a higher data density as compared to Wi-Fi. Li-Fi also provides high security as attackers can't capture the signals transmitted by the light source outside the walls of the room.

Li-Fi has a low ecological impact as it makes use of existing lighting infrastructure and is nonhazardous to use. Wi-Fi has low obstacle interference as compared to Li-Fi as the Li-Fi signals cannot pass through solid and opaque objects. Since Li-Fi is an emerging technology, it hasn't matured much in the market as compared to the traditional Wi-Fi systems

II. RELATED WORK

Li-Fi has much bigger applications than simply as a geo-location tool. Incorporating Li-Fi into the 14 billion existing light bulbs could provide more accessible and secure internet service.

The system, brutalize devices with the use of visible light communication. The transmitter used in this type of system is made using LEDs that transmits encoded information across to the receivers. This system can be used for communication in a free space that does block the optical link. When the receiver receives this signal sent across by the transmitter, it decodes it back and reproduces the original message. Li-Fi can be used to solve the issue of the decrease in the bandwidth of the radio frequency spectrum. This system can be used to maintain security and avoid road obstacles [2].

The system uses Wi-Fi for the web server communication and Li-Fi as the network infrastructure inside the home. The home devices can be controlled locally or remotely. Other part is hardware interface module, which renders appropriate interface between the sensors and the actuator of home automation system. No bandwidth is required and the speed of transmission is fast enough to prevent the naked eye from noticing the toggle. The speed of transmission is proportional to the frequency of toggling [3].

A Visible light Internet access communication system where the system uses visible light as downlink which can communicate at a distance of 2m. With the application of the pre-emphasis technology, a 3-dB transmission bandwidth of 130MHz is achieved. In the evaluation experiment, the test computer can access the Internet and play online video resources. The maximum downlink data rate is up to 30Mb/s [4].

The wireless internet service exhibits to the people through Wi-Fi technology in commercial and industries. It's working based on radio waves in the spectrum. These waves are very harmful to the diseased people, signal sensitive areas. Thus, it could not be utilized in environments such as hospitals, scan centers, airlines etc. To overcome these limitations, Li-Fi is the technology that is developed to work in such environments. The paper shows that Li-Fi performs harmless data transmission at high speed using light source [5].

The primary function of LED is for illumination. An investigation is done on joint illumination and communication systems that provide lighting and VLC system. Performance constraints set by illumination properties is taken into consideration using different kinds of luminaries, beam angles, LED lamp arrangements and considers reflections off different wall materials. A white-light phosphor-based LED adaptive data rate VLC system is then demonstrated and finally the achievable data rates are discussed [6].

Wi-Fi gives a speed of 150 mbps according to standards but it is not enough to fulfil the need of users on the network. In order to counter this drawback German physicist Harald Haas developed a new technology call Li-Fi. The paper discusses the many advantages and few drawbacks of Li-Fi over Wi-Fi. Li-Fi will not replace Wi-Fi but it will compliment Wi-Fi instead. Both the technologies can work together for the maximum utilization of unlicensed 60 GHz spectrum [7].

Research conducted on Visible light communication states its various features and advantages over the traditional wireless communication using radio frequency spectrum. It provides various features like high data rates, secure transmission and more frequencies as compared to the radio frequency spectrum. The visible light spectrum is 10,000 times larger than the range of radio frequency and can be used as an alternate for existing radio-based wireless communication technologies. It has advantages like no electromagnetic interference, low cost, and high data rate [8].

A smart vehicular communication system was built using Li-Fi technology which provides protection against vehicular collisions on the roads. Li-Fi is an emerging technology which uses the visible light spectrum for communication. This paper focuses on the safety on roads in which the headlights, which consists of LEDs acting as a transmitter, communicate with photo sensors acting as receiver. White LEDs used in the head and tail lights can be used efficiently for short range communication with the photodetectors. The application is cost effective as LEDs are cheap and simple algorithms are proposed for signal generation and transmission [9].

A home automation system uses a smartphone to enable any naïve user to operate all the appliances. The system has three components, an Arduino microcontroller for connecting the devices, a Bluetooth module for signal transfer, and a smartphone running the Android application. The system supports voice command for naïve users with command sensing. It decodes the user's voice command and extracts the exact meaning of the given command. The design is based on a standalone Arduino BT board and the appliances are connected to this board using relays. The smartphone interacts with the Arduino via Bluetooth. The main objective of the system development is to be low cost and scalable according to the requirements [10].

The initial designs and results of a small-scale prototype of a home automation system and vehicle communication system using light fidelity (Li-Fi) technology is the most effective solution for vehicles to communicate and avoid accidents. Indeed, the usage of LED eliminates the need for complex wireless network and protocols. Several case studies mimicking the vehicle to vehicle communication are explored in this work [11].

III. PROPOSED SYSTEM

The existing home automation system uses Wi-Fi for its wireless communication. Wi-Fi uses radio waves which have limited bandwidth. Privacy and security is always a concern since radio waves can easily penetrate through walls and thus act as a gateway for attackers. Using Wi-Fi for communication also narrows the scope for creating a multicast environment. Our system

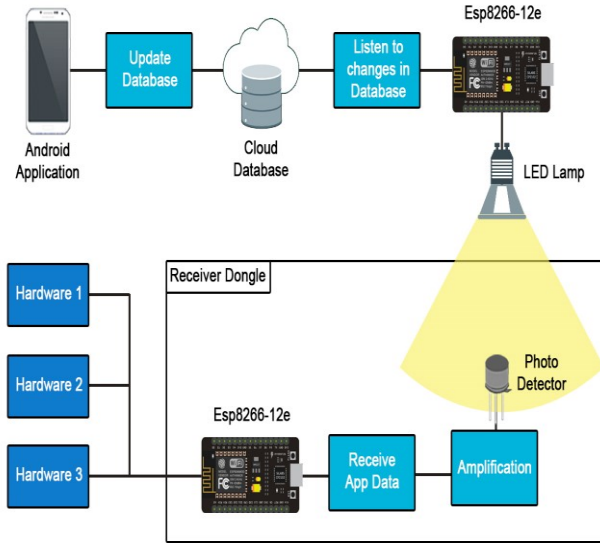


Fig. 2. System Architecture

Description

With our proposed system a user will be able to control their home appliances in different rooms with an easy and intuitive user interface on their smartphones. One LED Lamp is required in each room to control all the hardware appliances present in that room. The LED Lamp thus performs the dual functionality of automation and lighting the room simultaneously. Using Li-Fi in the system, also makes it more secure, cheap and fast.

The 'Advanced Home Automation using Light Fidelity' system uses an android application which helps to monitor and control the hardware devices remotely. Firebase, a real time cloud database stores the current state and the unique identity code of all the hardware's. The hardware's are segregated within the database based on room id. A high brightness LED Lamp is used as the transmission source and is connected to an ESP8266 ESP-12E which is a Wi-Fi chip and a Micro controller unit.

Whenever the database is updated, the ESP-12E creates a binary string which consists of the unique identity code of the hardware and its state. Lamp where every 1 bit is represented by an ON state and every 0 bit is represented by an OFF state. The LED Lamp thus turns ON and OFF based on the binary string. The toggling happens so rapidly that the naked eye cannot notice it happening. The LED Lamp of a room is identified and toggled based on the room id.

The receiving end is a receiver dongle which consists of a Photo Detector, Amplifier and another ESP8266 ESP-12E. The

Photo Detector detects the binary string of 1's and 0's transmitted by the LED Lamp which is then amplified and sent to the ESP-12E for further data processing. The ESP-12E has multiple I/O pins which can be connected to multiple hardware devices. The unique identity code helps to identify which hardware needs to be turned ON. Anytime hardware is manually switched ON or OFF, the receiving end ESP-12E updates the Database and notifies the user on their smartphone.

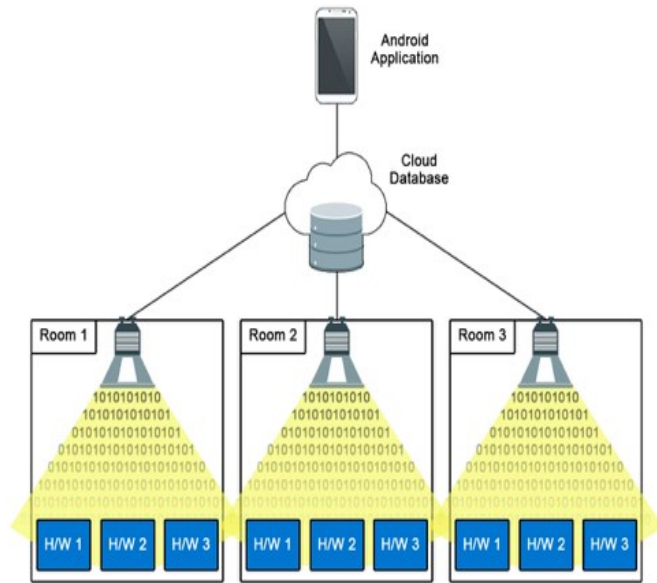


Fig. 3. Multicasting Connectivity

Fig.3 shows the connection between the android application, database, LED lamps and the hardware's. This is an example of a house with three rooms having three hardware's in each room. All the hardware's in a room can be controlled with the android application through the LED lamps. Once any application updating occurs, the room id helps to identify the LED in the room which needs to be toggled and the hardware in that room is turned ON or OFF depending on the command and the unique identity code.

IV. CONCLUSION AND FUTURE WORK

LI-FI solves many issues such as the shortage of radio-frequency bandwidth and is pointed at creating new communication channels with the use of existing equipment. Currently, the LI-FI concept is attracting a great deal of interest, as it provides an authentic and very efficient alternative to the wireless device which used radio spectrum. A system made up of LEDs can be used for transmission of data at rates better than that of the traditional Wi-Fi system while being secure and non-hazardous. Also, its impact on the environment is negligible. This system makes use of free space as a communication medium and the receiver is required to be in line-of-sight (LOS) with the transmitter. Even if they are not in sight communication can take place as long as the light is received up to 50% of its original strength after which the data rate may decrease.

Its uses are not restricted to homes but can also be used in cars, aircraft and also under water where Wi-Fi doesn't work very well. The Li-Fi market size was valued at USD 630 million in 2015 and is likely to grow at 80.8% CAGR from 2016 to 2023.

Smarter home appliances that talk machine-to-machine (M2M) using LED lights on electronics function as Li-Fi access points are already being extensively researched. Certainly, this will require manufacturers to see a credible reason to include the appropriate chips and firmware in these appliances to enable recognition by other controllers on the home network

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