



Analysis of Bluetooth, Wi-Fi, ZigBee and VLC

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ABSTRACT: Electronic communication is defined as the type of communication which uses electronic media to transmit information or message using computers, e-mail, telephone, video calling, FAX machine, etc. The various technologies which assist in this process are wired communication, Bluetooth, Wi-Fi, ZigBee, and so on. All these technologies use electromagnetic waves which is susceptible to interference and a health hazard for all living things. Moreover, increasing usage of internet demands increase in bandwidth which is a major drawback in case of Wi-Fi. This has led to an alternate solution so called Visible Light Communication (VLC) where transmission of data is carried out using light, hence overcoming the bandwidth restriction, and more secure compared to other technologies. It can be implemented in hospitals, aircrafts, underwater and other places where line of sight communication is possible.

KEYWORDS: Visible Light Communication, Bluetooth, ZigBee, Wi-Fi, Wireless communication.

I. INTRODUCTION

Wireless communication has made our lives easier but it comes with disadvantages as well. A major drawback is the availability of bandwidth. As the usage increases, there is a rising demand for a larger bandwidth which eventually increases traffic and compromises quality. To add on, usage of Radio Frequency (RF) systems leads to emission of Electromagnetic (EM) waves which is hazardous to human beings, plants, and animals because of which they are not used in hospitals and airplanes. Therefore, a new technology is required to overcome these shortcomings.

Communication using visible light is a possible solution for the problem stated above. Firstly, there is no bandwidth requirement which might reduce the burden on RF communication and improves quality as well. Secondly, it has no health risks which makes it suitable to be used in hospitals. Due to the absence of EM waves it does not react with nearby RF systems which makes it suitable to be used in airplanes. As it's not associated with frequency it is more secure to use light for communication when confidentiality is a priority.

Visible light communication is an emerging technology which uses visible light between 400THz and 800THz. VLC is a subset of optical communication and uses fluorescent lamps to transmit signals at 10Kbit/s, or LEDs for up to 500Mbit/s over short range. VLC can be employed as a communication medium for ubiquitous computing, because devices such as lamps, televisions, traffic signals, commercial displays and car headlights or taillights are used everywhere. This paper describes the details of implementation of text transmission setup in four different technologies and produces the analysis of the various communication parameters of these technologies.

II. LITERATURE SURVEY

- **Bluetooth:** It is a wireless technology standard utilized to exchange data between fixed and mobile devices over a short range making use of short-wavelength UHF radio waves in the industrial, scientific and medical radio bands, and building personal area networks (PANs). Bluetooth operates at frequencies between 2.402 and 2.480GHz comprising guard bands of 2MHz at the bottom and 3.5MHz at the top. It uses a technique called Frequency-Hopping Spread Spectrum (FHSS) and divides transmitted data into packets, and transmits each packet on one of the 79 designated Bluetooth channels of bandwidth 1MHz. It comes with the benefit of low power consumption, cost of Bluetooth devices being cheap, connectivity through obstacles, and voice and



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data exchange over Bluetooth enabled headphones, speakers, mouse, keyboard and so on. It also comes along with drawbacks such as short range communication, less secure, and lower bandwidth.

- **Wi-Fi:** Wi-Fi, which stands for wireless fidelity, is a wireless communication protocol that permits appliances to connect without using direct cables with the help of access points or Wi-Fi routers. A Wi-Fi router is an electronic networking appliance that transmits data packets to computer networks, thus providing Internet access to a myriad of devices connected to it. Wi-Fi comes with 2.4GHz band and 1 – 2Mbps data rate for 802.11 IEEE standard which employs FHSS or DSSS encoding scheme. When we consider 802.11a IEEE standard, it comes with a 5GHz band and up to 54Mbps data rate which employs OFDM encoding scheme. This network is convenient providing seamless connectivity, enhanced productivity by enabling usage of network by many users, mobility and easy reconfiguration in case of new users. However, it also poses security threats, comes with limited bandwidth availability which increases the burden on the network and is hazardous to the health of living things. It is mainly deployed in work environment, educational institutions and in IoT.
- **ZigBee:** ZigBee technology is specifically used for control and sensor networks on IEEE 802.15.4 standard for wireless personal area networks (WPANs). It operates at 868MHz, 902-928MHz and 2.4GHz frequencies covering 10-100 meters of distance. The data rate of 250Kbps is suitable for periodic as well as intermediate two-way exchange of data between collectors and sensors. This system is cheaper and simpler than the other proprietary short-distance sensor networks with long battery life, less power consumption, and easy implementation and installation. The disadvantages in this case are low data rate, security issue in case of confidential information, and not feasible for outdoor usage due to short coverage capability. It is mainly used in home automation and smart grid monitoring.
- **Visible Light Communication (VLC):** The RF communication is affected by intervention and issues related to high latency along with the requirement of a separate setup for transmitting and receiving RF waves. Visible Light Communication (VLC) is chosen as a preferred communication technique to overcome these limitations, the reason being its large bandwidth availability and resistance to interference from electromagnetic devices. VLC systems use visible light spectrum for communication that occupy the wavelength ranging from 380 nm to 750 and the corresponding frequency spectrum of 430 THz to 790 THz. The VLC receiver only receives signals from the transmitter residing in the same room i.e. supports only Line of Sight (LOS) communication which gets rid of the security issues that one faces in RF communication. As a visible light source can be used for both lighting and communication, no extra power is required for communication purpose and is not hazardous to the health of living things as well. Major drawbacks of VLC are interference from ambient source of light in the surrounding, inability to support LOS communication, and short range of communication. It can mainly be used in Li-Fi, hospitals, aircrafts, vehicle to vehicle communication and underwater communication.

III. PROPOSED METHODOLOGY AND DISCUSSION

Considering the drawbacks of Bluetooth, ZigBee, and Wi-Fi, we propose to use VLC where the data is sent over a short range with LOS communication and in places like hospitals and aircrafts where EM waves pose health threat and interfere with other EM devices. The system consists of a simple transmitter and receiver. The transmitter is made up of data source, microcontroller, and an LED. The receiver, on the other hand, includes LDR, microcontroller, and data sink.

The data is input from the data source to the microcontroller which converts it into binary format as the modulation technique used in VLC is On-Off Keying (OOK). At the output of the transmitter input data is converted into variations of light intensity using OOK. The LDR in the receiver captures the change in this light intensity and converts the electrical signals into binary data with the assistance of a comparator. This is further passed on to the microcontroller which decodes the binary into the analog form and is sent to the data sink.

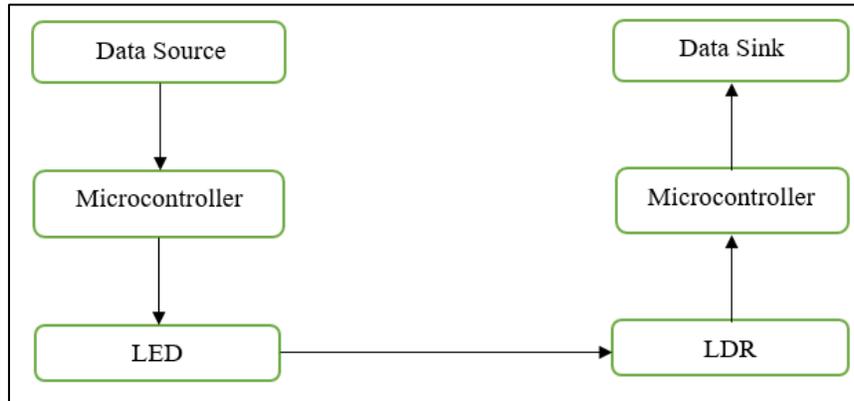


Figure 1: Block diagram of VLC

IV. EXPERIMENTAL RESULTS

To analyze the communication parameters of the four technologies, we tried simulating simple text transmission of data. The observed results in each case are as follows:

- Bluetooth- Observations made by simulation of Bluetooth technology:
 - 1) It can lose connection in certain condition such as when the devices are not in range.
 - 2) It is easy to design, cost efficient and communication is free if the device has installed Bluetooth.
 - 3) Data rate of Bluetooth is less compared to Wi-Fi but it has capacity to transmit different kinds of data including audios and videos.
 - 4) Security is poor in Bluetooth technology when compared to other technologies as any device within the range of the sender can receive the data. However, an option to disable Bluetooth's discoverability feature is always available. The sender can send identification signals to all devices within range, inviting for a connection. The receiver can remove Bluetooth connection settings on devices paired with unknown accessories to avoid data considered as threat.

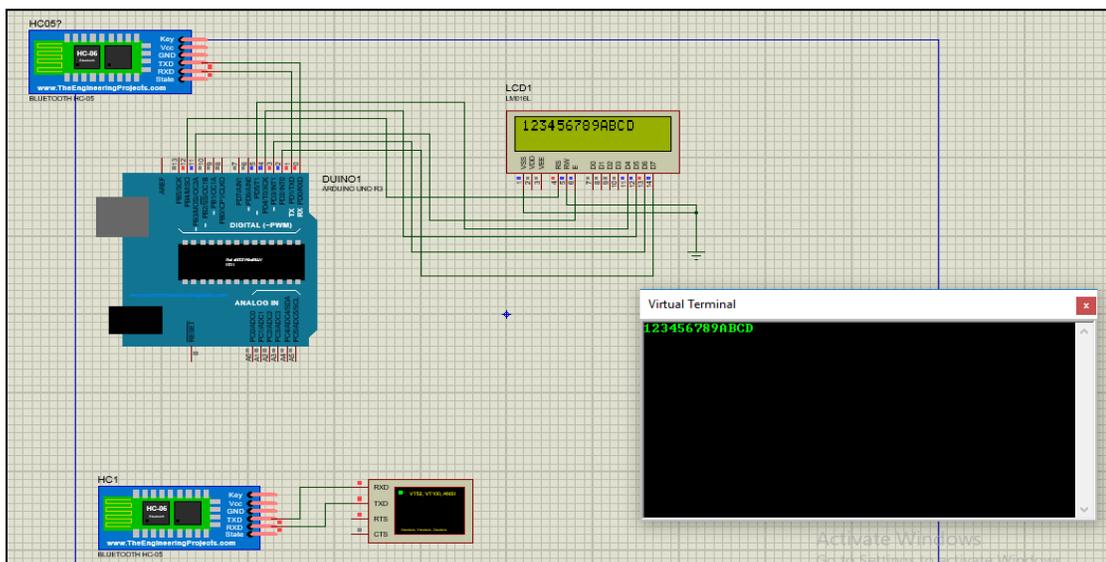


Figure 2: Simulation of Bluetooth



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- Wi-Fi - Simulation of Wi-Fi module entirely is impossible as the Wi-Fi module (ESP8266) is required to connect physically to the Wi-Fi access. Therefore, the simulation in this case was achieved using RF module. Observations made while simulating RF wireless communication:
 - 1) Once the library is installed it is easy to develop and design as it has few pins and can be interfaced with most of the components
 - 2) The range limited to 30 meters as beyond this the signal strength reduces.
 - 3) The speed of transmission is faster than most of the other technologies.
 - 4) This can be implemented anywhere as the RF signals are capable of penetrating walls, hence need not be a route directly from transmitter to receiver.

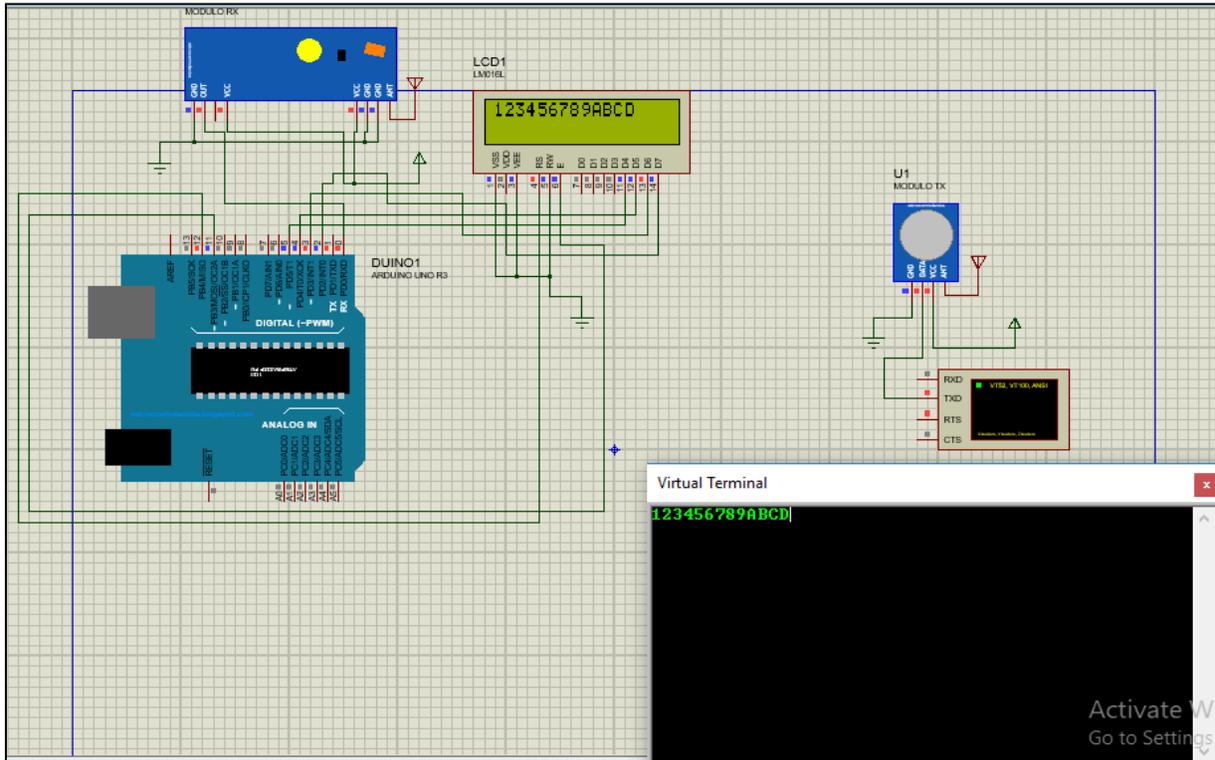


Figure 3: Simulation of Wi-Fi

- ZigBee - Observations made through simulation of ZigBee technology:
 - 1) It can be easily designed because of only two terminals on the module.
 - 2) It cannot be implemented outdoors because of short range communication.
 - 3) It requires virtual connection between receiver and transmitter which is hard to maintain under all circumstances.
 - 4) It cannot have many end devices.
 - 5) ZigBee has low transmission rate and it is risky to use this technology for highly secured communication.

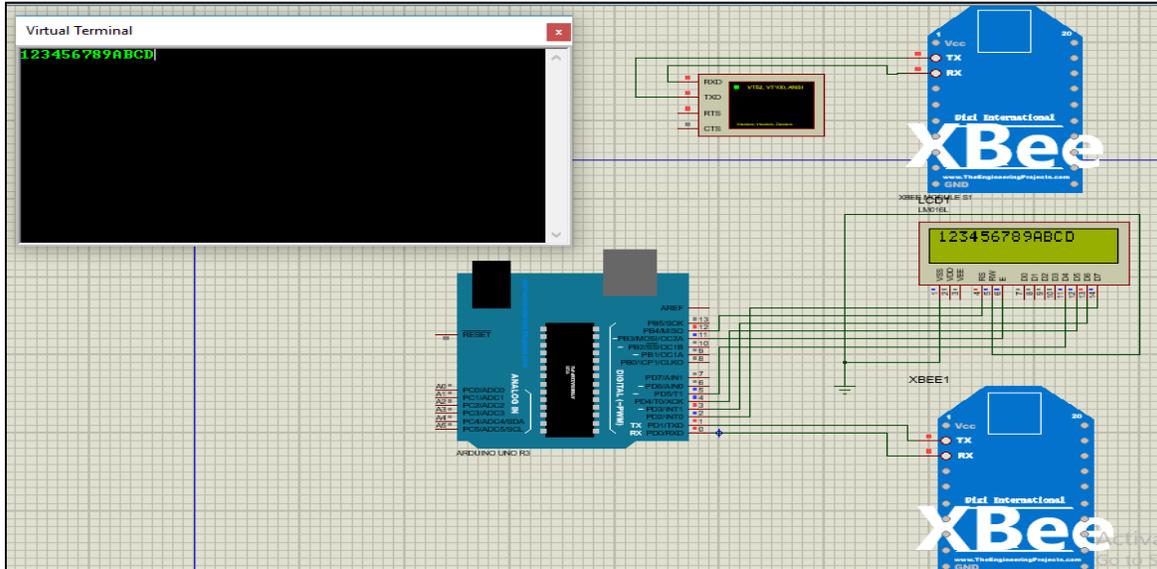


Figure 4: Simulation of ZigBee

- VLC - Observations made from simulation and hardware implementation for VLC:
 - 1) The whole circuit cannot be simulated unlike other technologies because LDR functionality cannot be simulated.
 - 2) The system works until the receiver is in the range of light of the transmitter.
 - 3) The cost of the hardware implementation is economic compared to other technologies.
 - 4) The data cannot be transmitted when the path of light is obstructed which makes this method more secure.



Figure 5: Hardware implementation of VLC



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From the above observations we have analyzed the following:

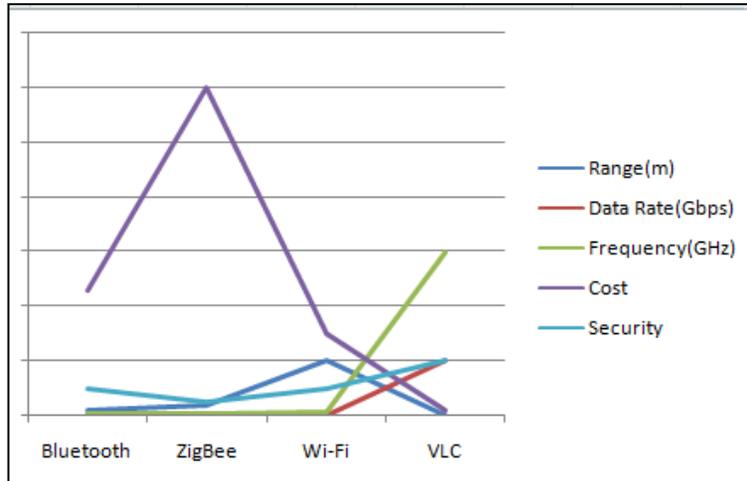


Figure 6:Graphical analysis of communication parameters

Parameter	Bluetooth	ZigBee	Wi-Fi	VLC
Range	10m	10m-20m	45m-100m	Around 5cm (as per the hardware setup shown above)
Data Rate	3Mbps	20-250kbps	11Mbps-450Mbps	Upto 100Gbps
Frequency(Bandwidth)	2.402 GHz - 2.480 GHz	2.4GHz	2.4GHz and 5GHz bands	300GHz
Energy efficiency	Low power consumption battery driven technology	Low power consumption technology	Need to configure router by connecting to power source	Energy efficient technology as LED uses less energy
Cost	Cheap	Moderate	Expensive	Cheaper
Privacy(Security)	Requires consumer's consent to pair but poor security	Highly risky to be used for official private information.	Does not ask consumers' permission explicitly.	Consumer can choose to receive data. Suitable for private information.
Compatibility	All Bluetooth enabled devices	Devices must support ZigBee protocol	Compatible with WLAN 802.11 a/b/g/n/ac/ad devices	Compatible with IrDa devices

Table 1:Comparison of the four technologies



V. FUTURE WORK

Light Fidelity or Li-Fi is a visible light communication that is built on an idea of using light bulbs as routers. With faster transmission rate and its capability to maintain private information, we can surely see this technology being the future of Internet. With increasing connection to the internet every day, we can expect traffic issues in the current technology setup. However, with the help of existing light bulb we can have access to faster and secured technology without the interference with radio signals. There are multiple applications of Li-Fi proposed, such as, Military, Underwater communication, Vehicle to Vehicle communication, Internet of Things, Street Lighting etc.

The following block diagram showcases Li-Fi used in home automation. There are few disadvantages of Li-Fi as well. It cannot be used outdoor easily because of sunlight or in darkness in the absence of LED bulbs. However, with the combination of different technology we can develop a home automation design that overcomes disadvantages and uses advantages of these technologies to the fullest. Home Automation or Smart Home controls appliances, lighting, climate and home security systems. Wi-Fi can be used to control the environment around and security systems that can help us in maintaining required ambience at home. ZigBee with mesh topology and its support to multiple nodes on single network will enable us to use it in controlling different appliances like HVAC systems. Bluetooth on the other hand can be used to control different low powered devices that do not require lot of bandwidth. Li-Fi can be used to control appliances where security is a key as Wi-Fi is prone to hacking. With Li-Fi we can download about five movies standing under a light bulb for a minute.

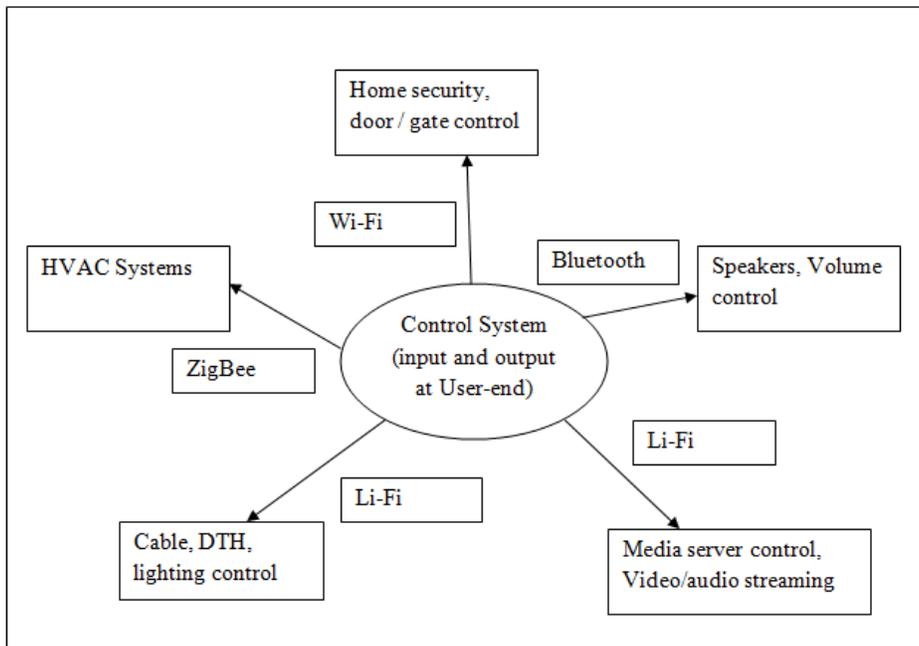


Figure 7:Home automation using the four technologies

VI. CONCLUSION

We can conclude that VLC can be implemented in places where EM waves seem to be harmful and the communication is LOS. This helps in taking the load off other technologies which can be put to use in more essential situations. The VLC setup has been tested for transmitting image, audio and video as well which shows that transmission of large data is possible by using light. To increase the range of communication, an array of LEDs or LED bulbs with higher intensity can be used at the transmitter side and an array of photo detectors with higher sensitivity can be used at the receiver side.



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