Application of li-fi technology in home automation system

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Abstract : *This paper reviews about the new form of communication i.e. Light Fidelity (Li-Fi) and its application to various industries especially the home automation system. This technology is based on the principle of visible light communication where a beam of light is used to generate a stream of binary code which in turn is interpreted as the digital signal for processing the required information. The main advantage of using the visible light communication is that it is fast, reliable and widely ranged. The property of the light wave that it has a shorter wavelength in the chart of the electromagnetic spectrum makes the visible light more frequent than the traditional radio wave.*
Keywords: *Light Fidelity, Visible light communication, electromagnetic spectrum*

Introduction

Communication has been an essential part of human existence since the humanity evolved. During the early stages of evolution, human tends to use the sculptures and signs to communicate with each other over long distances. This concept was overpowered by the introduction of letters and telegrams. However, this process is too slow like anything. The transmission of information over digital media was introduced by Morse code which was later evolved as telegraphs, fax and then the widely known source of transmitting and receiving information that we still use today was termed as internet. The internet industry got a big hike with the introduction of wireless communication since this helps communication of the information over a long geographical distance (almost the other side of the globe) in a matter of seconds that too so economically replacing the old Ethernet cables. Now-a-days wireless communication has become a vital ingredient in not only the communication but also in our style of living.

As the time passes, the concept of wireless communication opened new ways of thinking and interacting with the outside world. Besides a person to person network, wireless communication or wireless fidelity (also termed as Wi-Fi) helps us form a person to device network where a person can interact with all the devices in a home with just a click of his mobile device. This new technology was termed as private network or precisely home network. The home network focuses on the connection and communication among the devices that has its own unique address i.e. IP address and their interaction with us. However, this type of wireless communication works on the Radio waves which has a very special place in the EM spectrum. The advantages of the radios waves from its range to connectivity are unlimited. However, the tendency of the radio waves to pass through the walls makes our private network not so private. And as the famous proverb that says "Necessity is the mother of all invention", the

necessity to have a real private network for the human race gave birth to all new form of communication, Visible Light Communication or VLC.[1][2][3]

Visible Light Communication

The term used to identify a form of communication using the visible light band of the Electromagnetic spectrum is known as Visible light spectrum. As we see from the diagram below, the visible light has the advantage over the radio waves with shorter wavelength which leads to high frequency and high energy.[5][6]
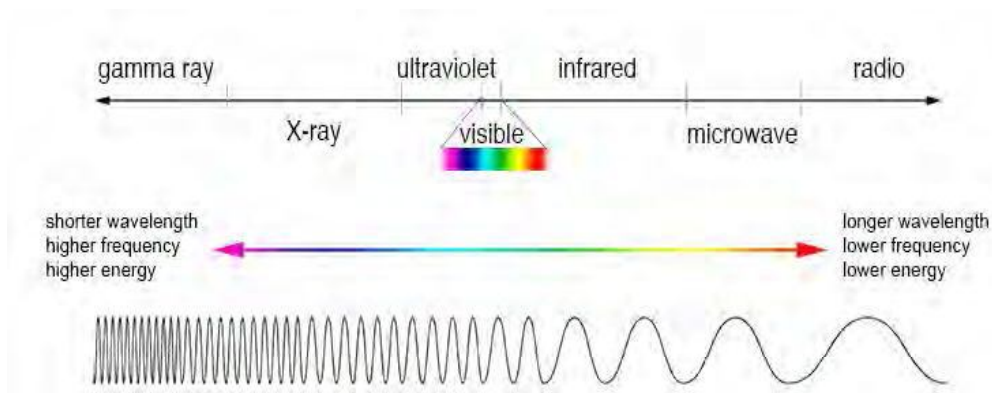

Fig1. Electromagnetic spectrum and the visible light

Thus, the visible light was assumed to have more bandwidth than the RF spectrum and when the technology was tested, it was proved that the visible light spectrum was 10,000 times bigger than the traditional RF spectrum giving huge amount of communication channel to the world and also reducing the risk of the spectrum crunch.[7][8] A spectrum crunch is a position where the introduction of additional RF spectrum will be ineffective. The visible light communication was later evolved as Light Fidelity or Li-Fi.

Li-Fi works on the principle of modulating the high frequency visible light in such a way that it is not perceived by the human eyes, but this process generates series of binary codes which will later be received by the photo-detector and later interpreted the same way as in the case of Wi-Fi.

Figure 2 can be used to understand the working of Li-Fi. The information from the internet and the server is received by the transceiver using the same old Radio waves, after that the information is used by the lamp driver to modulate the light waves emitting from the LED bulb making the bulb to switch between the on and off position so fast that it can't be perceived by the human eye. This fluctuation in the light beam is sensed by the photo-detector which sends the signal to the amplifier which in turns sends the signal to the data processor and the stream of binary digits is converted to meaningful information and then displayed on your respective digital device.
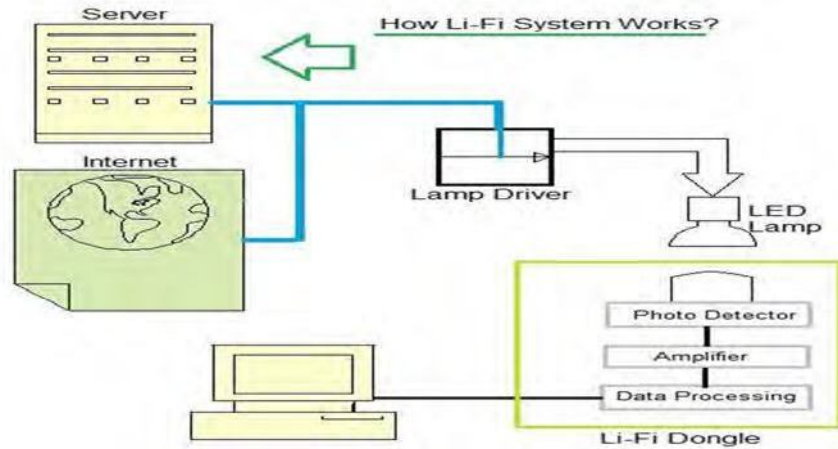
Fig2. The architecture of Li-Fi system

Why does it even matter?

Now, after getting an in-depth knowledge of the visible light communication and all that Li-Fi process, you must be asking yourself that question that why does it even matter to you? There might be a situation of internet congestion going on in the world which is causing the quality of connectivity to degrade and we are not far away from a spectrum crunch but still you are getting a sufficient internet speed both downlink as well as uplink with those high quality data plans. Well, then you must be amazed to see the wide possibilities of Li-Fi.

1. Apart having such a huge range of frequency bandwidth, this type of communication can provide you data rates as high as 100 Gbps which is experimented in the most ideal environment possible. The average transfer can be around 3-4 Gbps which is more than the 52 Mbps given by the RF device.[9]

2. Visible light has a tight illumination area as compared to the spreading of beams in case of Wi-Fi which can give 1000 times more data density than the Wi-Fi which means way more than data in a single data stream.[10]

3. The radio waves surpasses the walls of the house which leads to illegal intrusion in a private network but that's not the case with the light based communication and that doesn't mean we would be restricted to have a line of sight communication with the bulb but the series of those lights can act as each one of the access point in the network and each of those access point will keep record of the information passed from the previous access point.[11][12]

Home Automation Using Li-Fi

Now, the idea of home automation is not new to the world. The concept behind the home automation is that all of the devices inside a home can be connected using a home network such that they can interact with each other automatically or through the user's interference. Imagine, when you woke up in the morning, and turn off your side lamp off, the particular information can be sent at a completely different part of your home that sets your water heater on.[13] A more useful example could be, a biometric authentication at your doorstep that sets the password lock on/off your house that

nobody knows except the computer!

When we thought of such a huge diverse communication among different devices you need a more sophisticated form of network rather than peer-to-peer network. For decades, internet or the World Wide Web in its wireless form is identified as such form of network. However, as we have discussed earlier, this form of wireless communication involves transmission of radio waves from one client across the server to another client. These radio waves will penetrate through the walls of your house and can be exposed to a possible intrusion that just requires a transceiver and a way to access your IP address. [14]

However, with the introduction of the Li-Fi technology, your private network will remain private as long as you want it to be private. Moreover, the extended data speed and range along with accuracy will provide a more reliable communication system for home automation.

The whole system will work like this. A central node will act as a server, along with a transceiver and a photo-detector is connected. The signal from a client i.e. mobile device in the form of visible light is transmitted, which the photo-detector will detect and process the information(IP) and forward the command to the access point of the network i.e. LED bulb. The transceiver connected to the LED will operate the lamp driver, which in turn control the modulation of the bulb broadcasting the entire information in the room. The device which has the identical IP address configured using the Network Interface Card (NIC) will respond to the request of the LED and that's how a connection is set up. Then the two devices can communicate where LED would work as a router similar to the Wi-Fi router.

Conclusion

With the enormous increase in technology over the last few decades, the field of connectivity has been quite taken care of. The whole world is getting connected be it person, places or objects. With the increasing demand of communication channels across the globe, reusing the already existing technology for communication is the best we can get. The visible light communication or better known as Li-Fi technology is the biggest leap, the world can see. In near futures, we may be able to integrate the concept with nano-electronics to make the whole system fit inside our digital device.[15][16] Then we could imagine a new era of communication where we have fast, reliable and still widely range internet system across the globe.

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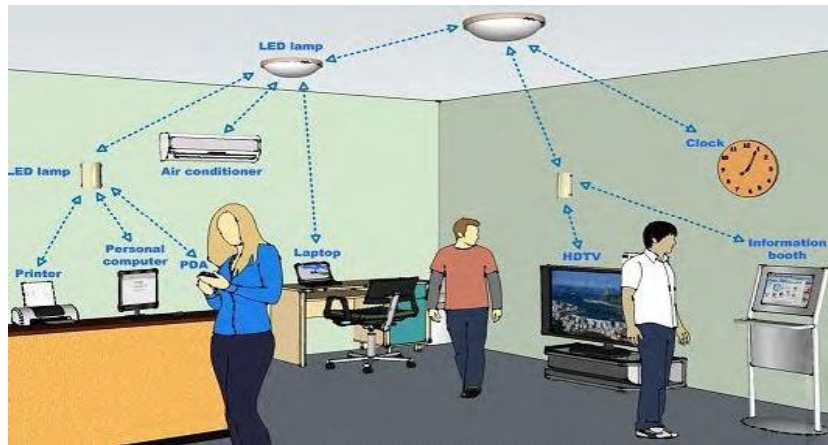
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