Li-Fi: Data Onlight Instead of Online

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ABSTRACT

The demand for wireless data is increasing at an exponential rate hence to cater the demand, various technology options are to be looked for and need to be implemented. An emerging technology using Visible Light Communications (VLC) for high speed wireless communications is Light Fidelity dubbed as Li-Fi. To provide high speed communication, light is modulated without interfering the main purpose of lamp that is of illumination. LEDs are considered as a key component to be used in transmission because of its low cost and Omni-presence. In this paper in section II, brief history related to the development of this technology has been discussed. The aim of this paper is show the potential of using light source and to exploit this as a medium for providing communication. Various applications where Li-Fi has been put to use already are discussed.

Keywords- **Visible Light Communications, Light Fidelity (Li-Fi), LED, Omni-presence**

I. INTRODUCTION

Demand for wireless data is increasing day by day which is escalating the congestion in radio spectrum. In present scenario the bandwidth capacity which is available is finite & is not capable enough to sustain with the constantly increasing demand of wireless data. Wireless Fidelity dubbed as Wi-Fi has been in use from almost years to provide the internet services to all the required places right from home to humungous organizations. But it has limited bandwidth of about 54-100 megabits per second (Mbps). With High definition video & audios available for the viewers, it is becoming intricate to transfer them to the user flawlessly. Present standards of Wi-Fi are being pushed afar their limit to handle today's need to support high end media. The problem of speed & consistency even doubles when support is to be given to multiple devices because of splitting up of bandwidth between devices. The beauty of Wi-Fi is its easy & simple to set up network but threatening part is to provide security. Bluetooth enabled devices may also create interference in its data transmission. To overcome technological boundaries of Wi-Fi, a new paradigm is in, which is Li-Fi. An emerging technology using Visible Light Communications (VLC) for high speed wireless communications is Li-Fi. The term Li-Fi has been coined by Prof. Harald Haas who is one of the scientists in the team, to develop this technology along with Dr. Gordon Povey & Dr. Mostafa Afgani at the University of Edinburgh. It uses white LED light bulbs to transmit the information as well as fulfilling the purpose of illumination. Through fast and slight variations of the current (which is applied to the LED), the optical output can be made to vary at very high speeds. The variation caused in the current which is passed to the LED will carry data at high speed and cannot be seen by the human eye.

II. CONCEPT TO EXISTENCE

The notion of using visible light for data transmission is not totally new. Research based on this technology started in 1880. The first VLC transmission, which is also considered as first wireless transmission in the world was done by Dr. Alexander Graham Bell on 3 June 1880 in Washington D.C. Voice message was sent by modulating light. That system was patented and named as Photo phone. That time he used sunlight as source, but the unpredictable nature f sunlight was the drawback [8],[9]. Today almost similar projects are in process using more reliable LED technology.

The potential of using light used for wireless communications was suggested by Dr. Sergius P.

Grace, of the US Bell Telephone Laboratories in 1931 [9].

Reasonable Optical near joint access (RONJA) was devised in year 2001 in Czech Republic. RONJA used beams of light to transmit the data with a rate of 10Mpbs. The range of the device was 1.4 km approximately. A Visible Light Communication system was developed by Dr. Stefan Spaarmann in 2002 but prototype of that could not be build because of lack of funds [9], [10]. In year 2003 a consortium was formed by major Japanese companies to develop, plan, research and to regulate Japan's own visible light communication systems. This consortium was named as Visible Light Communications Consortium (VLCC). In 2004 the Visible-Light Communications Consortium demonstrated the use of LED-light systems at CEATEC Japan. There, VLCC demonstrated the use of LED-light systems in high-speed transmission of data in computing devices. VLC developed by NEC was showcased by Fuji Television at the International Broadcast Equipment Exhibition (Inter BEE) 2007 in Japan. In that demonstration a LED-backlit LCD television operated whilst transmitting information to a personal digital assistants (PDA) via light. The device also enabled the information to be sent securely to chosen individuals [9]. VLCC gets involved in standardizing work of visible light communication technology in 2007 to make it more safe and secure. For that Japan Electronics and Information Technology Industries Association (JEITA) was formed. This association created visible light ID system. VLCC and the International Infrared Data Association (IrDA) announced an agreement in 2008 to establish global standards for low-cost infrared technology for wireless transmission. They emphasized on combining widely-used mobile phone IrDA technology and new visible light communication technology for commercial applications [10]. Constant Research was going on for increasing the transmission range of VLC in 2009. The Center for Ubiquitous Communication by Light (UC-Light) at the University of California seeks to develop VLC technology to further in 2010 to allow communication between a wide variety of electronic products, such as high definition televisions, information kiosks, personal computers (PCs), personal digital assistants (PDAs) and smart phones [10]. The range as well as speed of data transmission was rapidly improving. A group of researchers of Siemens and Heinrich Hertz Institute in Berlin in 2010 demonstrated data transmission of 500 Mbps using white LEDs over a distance of 5 meters. This rate is much higher than present Wi-Fi transmission [8], [9], [10]. At TED global in July 2011 Prof. Harald Haas demonstrated High Definition video from a standard LED lamp.

III. DATA TRANSFER IN LI-FI

The basis of Light Fidelity is on the thought of using light for transmitting the data in place of Radio waves. Although any light source can be used as transmitter but some of them have practical priorities based on their operational properties. For example some light sources may quickly break down by frequently switching it on and off for transmission. Hence light source like incandescent lights may not be

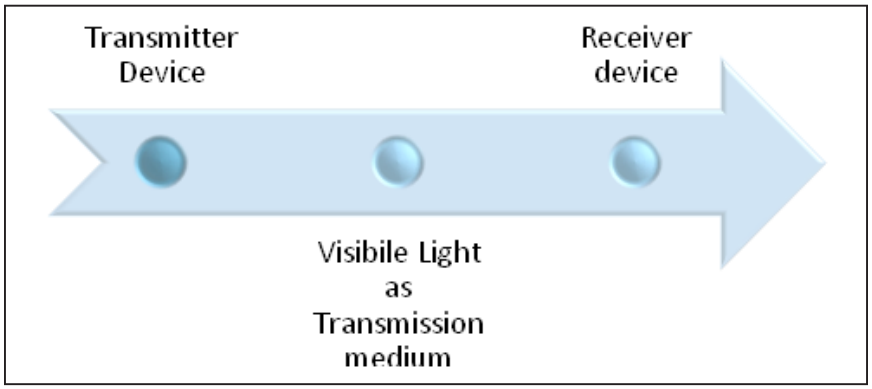

Fig.1 Data transmission from source to destination by visible light as medium

recommended. As stated in section I that LED light bulbs, key component in data transfer, will be equipped with transceivers which will receive as well as transmit the data.

As LEDs can be switched on and off much faster than we perceive and this on-off motion can be used to represent binary digits 0's and 1's . Such a sequence of light variation will enable for data flow.

Orthogonal Frequency Division Multiplexing (OFDM), modulation scheme is the basis of visible light communication or wireless optical communication [8]. The signal send by transmitter is to be converted into the data. For this purpose receivers are to be used. For serving the purpose of receivers to convert the light into electric pulses photodiodes are used. These photodiodes demodulates the optical signals into actual data [11]. Present Data Rate is 100kbps to 100mbps by using different modulation schemes for different applications.

IV. APPLICATION AREAS

A. Smart Lighting

With the advent of VLC smart lighting will be provided which in turn will be used for illumination as well as communications. Various types of controlling can also be done by using this concept. In all energy consumption and wiring incorporated will also be reduced as lights are already on for illumination, so no additional energy is required for data transmission [5], [6]. Its use can also be extended in Projection Display Systems. Lamp Technology which is electrode free using Li-Fi has been created for projection display applications [12]. An optics set is used to convert light into an output which is efficiently accepted by the projector. It offers flexibility in the type of output. It allows the system integrator to convert between collimated and focused output. This flexibility helps in the use of the same lamp for many projector types [1].

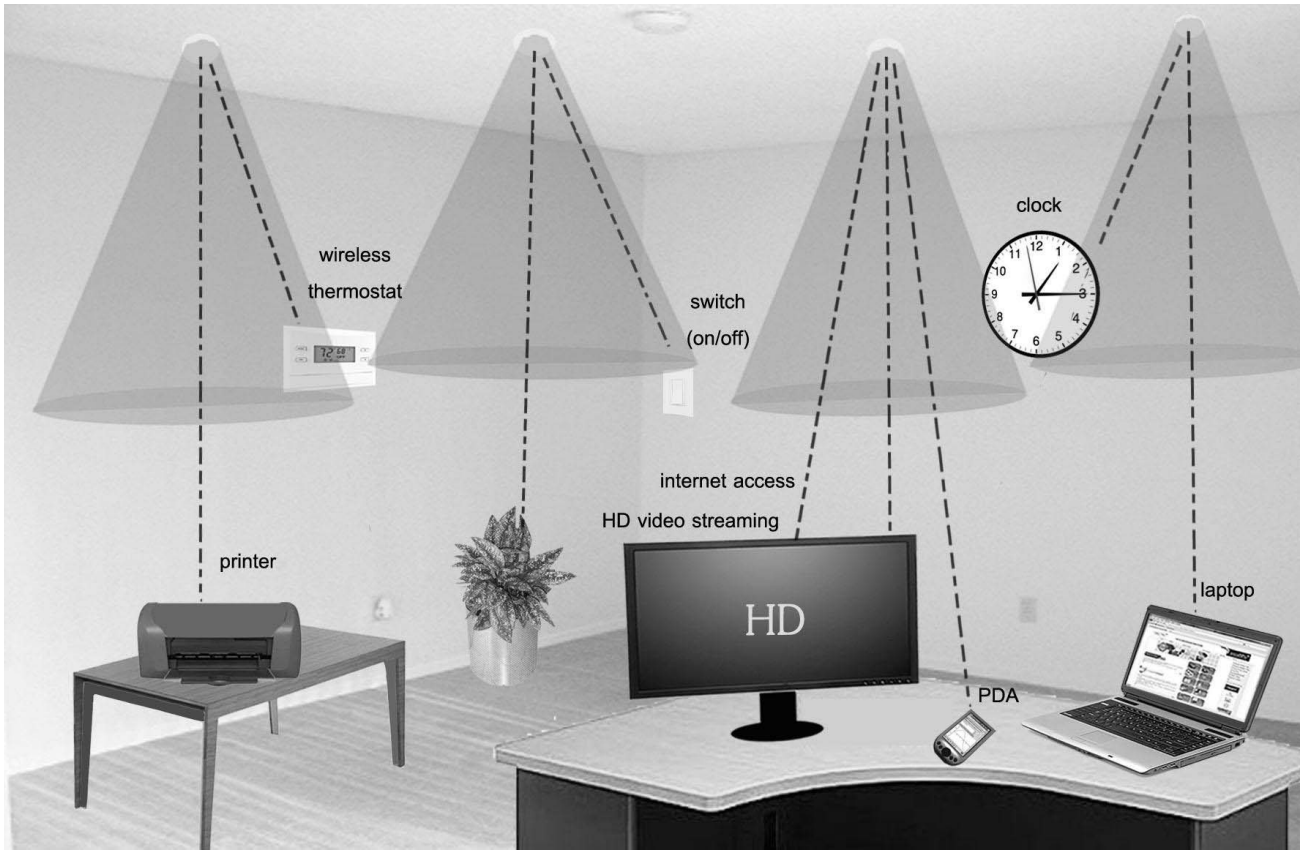

Fig. 2 communication via Li –Fi [13]

B. Precision Lighting Solution for Medical and Analytical Applications

Lambda XL is the new microscopy and analysis light source showcased by Sutter Instrument [3]. Earlier xenon HID light sources were used which has been redesigned using the Li-Fi light source [4]. By using such light sources in hospitals and laboratories, maintenance costs can easily be lowered down because its lifetime has been increased more than five times relative to the used previously. The problem of HID (High intensity discharge) sources was flicker and variation in light intensity which is removed in this. Features like stability and quality imaging are provided, hence making it useful for high speed fluorescence microscopy analysis.

Using VLC in hospitals and in healthcare will be highly advantageous as mobile phones and Wi-Fi's are obstructed in some parts of hospitals, especially near MRI scanners and in operating theatres [6]. The prototype of mobile phone incorporated with VLC systems was presented by Casio at the Consumer Electronics show in Las Vegas in January 2012. Also in Germany, a company named *Axiomtek Europe* presented such a product at the Embedded World exhibition. [7]

C. Underwater Communications

For short distances underwater visible light can support high speed data transmission as RF doesn't work. This could enable the divers and underwater vehicles to pass voice messages to each other [6]. In such systems, microphone is installed in the LED light. The voice from a diver will be picked up with that microphone and will be sent to other diver over the light. The second diver will receive the light, accept the audio signal from the light and send acknowledgement to the other diver. the voice through a bone-conductive speaker. This underwater communications technology will make scuba diving not only more enjoyable but also safe and more secure [7]. In 2008, Nakagawa Laboratories based in Tokyo demonstrated underwater visible communication technology for scuba divers.

D. Aviation

In air travel RF is undesirable in passenger compartments. LEDs are already used for illumination and hence can also be used to provide media services to passengers in place of wires. This will reduce the construction cost of aircraft and weight as well. [6].

The application areas of it are not at all limited to the few which are mentioned above instead there are many more. In near future various Li-Fi products will be launched for industrial and for consumer market as well.

V. CONCLUSION AND FUTURE SCOPE

To provide high speed communication, light is modulated without interfering the main purpose of lamp that is of illumination. Constant Research is going on for increasing the transmission range and data rate of VLC. It appears to be a potential technology for creating endless applications but many areas are still to be improved to reach a state of maturity. According to Dr. Suresh Borkar, communication expert and faculty member at Illinios Institute of Technology is regarding the hardware which is required when optics is interfaced with electronics. Also this technology needs to be miniaturized by developing application specific integrated circuits, optical devices inclusive of photodiodes as receivers. Many other challenges will also incur in the path of its research and implementation but soon Li-Fi products will complement the consumer market with its applications. Soon the data is going to be *onlight* in place of *online*.

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