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Analysis of optical communication system with application to led and VLC

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Abstract
In this paper, the internet transmission at the backbone is handled by the Optical Fiber Infrastructure that can achieve data speeds on the order of Tb/s. On the other hand, these high data rates at the backbone part cannot be perceived by the end users. Since the existing bandwidth cannot satisfy the required capacity and speed demands, as well as multiple technologies contemporaneously share the same bandwidth (Wi-fi, Bluetooth, cellular phone network, cordless phones), scientists and professionals have focused on new research areas in wireless communications.

Keywords: Analysis, optical communication, led, VLC

Introduction

Depending on the technological developments, the variety and quality of the communication devices and applications running on these devices have increased dramatically. These high quality applications require excessive data transfer capacity and speed. Much of the internet transmission at the backbone is handled by the Optical Fiber Infrastructure that can achieve data speeds on the order of Tb/s. On the other hand, these high data rates at the backbone part cannot be perceived by the end users. Nevertheless, it is not always beneficial and conceivable to deploy a cable infrastructure to every point of a site. Therefore, the importance of wireless communication increases day by day and is being widely used in the last-meter such as home, office and campus environments. Even though wireless communication is favorable in terms of cost, practicality and ease of operation, it brings about the bottleneck problem. RF waves that fall beneath the 10 GHz frequency portion of the electromagnetic spectrum have been widely used in wireless communication. However, since the existing bandwidth cannot satisfy the required capacity and speed demands, as well as multiple technologies contemporaneously share the same bandwidth (Wi-fi, bluetooth, cellular phone network, cordless phones), scientists and professionals have focused on new research areas in wireless communications. An alternative solution proposed for this first-meter bottleneck problem is shifting the working frequency interval to the unlicensed 60 GHz band. By this way, it is desired to widen the bandwith and achieve higher data rates [1]. Given the name WiGig, and standardized by Wireless Gigabit Alliance [2], it has become possible to reach about 6-7 Gb/s data rates with this technology [3].

However, shifting towards the right side of the frequency spectrum, reduces the wavelength of the electromagnetic waves. The propogation range of short wavelength signals is very limited. As the signal spreads over longer distances, the error rate increases due to the weakening of the energy [4]. Therefore, WiGig technology is intended to be used for data communication at high speeds in more enclosed areas.

Regarding to these quests, it is desired to utilize the mm-length electromagnetic waves ($\lambda <=$ 1mm, f > 100 GHz) with the aim of enabling supplementary communication channels. Commuication with the mm wavelength on the right side of the spectrum is called Optical Wireless Communication (OWC). Data transfer on the infra-red band is already provided. Around 100 million electronic devices per year take place on the shelves adopted with infra-red technology. Moreover, the next generation wireless communication technology 4G and the follower are not built on a single technology. These Technologies are desired as an integrated top-one system that will compromise multiple technologies working in harmony.

The OWC technology is expected to be an important figure of 4G and 5G systems especially in the section that the end users are connected to the internet [5]. The outstanding advantages of OWC when compared with Radio Frequency Communication (RF) can be listed as follows [6-10]:

- Unregulated 200 THz bandwith in the range of 155-700nm wavelengths.
- No licensing fee requirement
- Optical signals can not pass through walls like radio waves penetrate. Therefore, the signals emitted in a room provides significant benefits in terms of security by staying in that room. For long-distance communications Line-of-Sight (LoS) is essential, that is, the sender and the receiver must see each other directly. Any intervening situation or barrier can be easily recognized. Thus, OWC is significantly preferred in the military and state mechanisms that require high information privacy and security.
- Stay of signals in the room or office, elliminates the possibility of any interference in adjacent rooms or offices. By this way, each room will constitute a cell and the capacity productivity will rise to the top levels.
- The equipment used is cheaper when compared with RF devices.
- Optical signals are not as detrimental as RF signals to the human health.
- OWC requires lower energy consumption than RF systems.

Data transfer by using the infra-red portion of the spectrum is already provided. Latest research activities have been focused on achieving data transfer simultaneously with enlightenment by means of using LED lighting equipment. These energy stingy and cost effective LED devices are desired to be used for data transfer without using RF signals, especially in short ranges. By using visible light, it is intended to achieve wireless communication in the environments and situations such as airplanes, hospitals etc, where it is not convenient to use RF waves.

The idea of illumination and data communication simultaneously by using the same physical carrier is firslty suggested by Nakagawa et al. in 2003 (Nakagawa Laboratory). Their studies [11-15] pioneereed many following research activities. Later on, the Nakagawa Laboratory went into coperation with the famous Japan technology firms and they established the Visual Light Communication Consortium (VLCC). Followingly, many research activities have been done that the most outstanding is the European OMEGA Project. Eventually, in 2011, IEEE completed the release and visual light wireless communication gained a global standard with the name 802.15.7-2011 [16]. IEEE Standard for Local and Metropolitan Area Networks--Part 15.7: Short-Range Wireless Optical Communication Using Visible Light [17]. Though a standard of visual light communication has been released in 2011, prevalent usage of this technology will take further time.

Hence we investigate the fundamentals and challenges of indoor VLC systems. We explore the fundamentals and challenges of indoor VLC systems. Basics of optical transmission such as transmitter, receiver, and links are investigated. Moreover, characteristics of channel models in indoor VLC systems are identified and theoretical details about channel modelling are presented in detail.

Fundamentals of VLC

In recent years, one of the ideas put forward for wireless optical communication is the visible light communication method. The signals in the 380-780 nm wavelength interval of the electromagnetic spectrum are the light signals that can be detected by the human eye. It is possible to achieve illumination and data transfer simultaneously by means of LEDs that is the prominent lighting equipment lately. By this way, both interior lighting of a room and data transfer will be achieved without the need of an additional communication system. This technology is given the name of Visual Light Communication. Basic configuration of a VLC communication system is given in Figure 1.

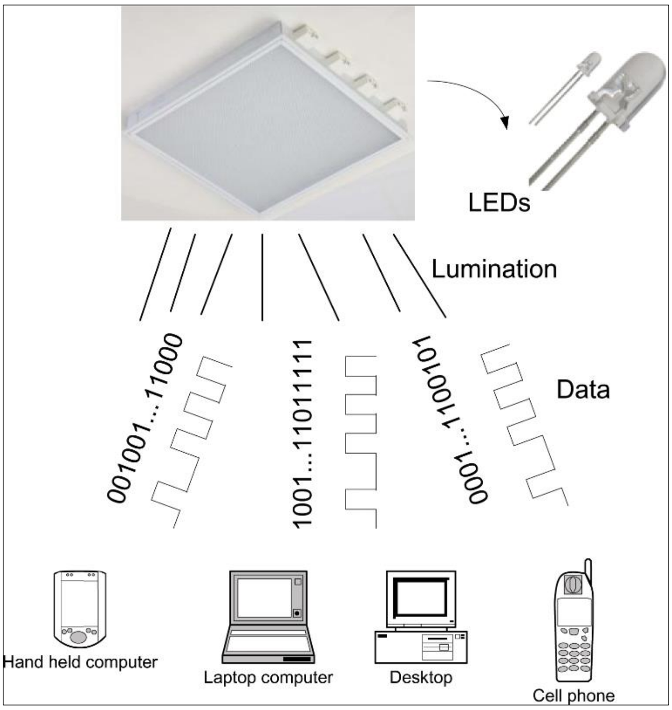

Fig 1: Basic VLC configuration

Fundamental entries in a VLC system are the transmitter (LEDs), receivers (photodetectors), modulation of data to optics and the optical communication channel as shown in Figure 2. We will discuss these main figures of a VLC system in the following section in detail.

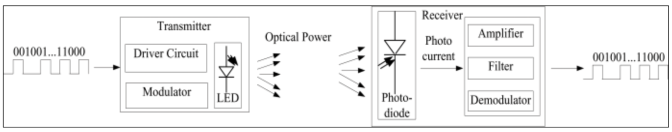

Fig 2: Block diagram of a VLC architecture

Transmitter

There are different possible light sources used for illumination. However, Laser Diodes (LD) and LEDs are the two most popular ones among these especially preferred for optical data communication. Since the purpose of this study is about VLC, that is the concept of maintaining illumination and data transfer simultaneously, discussion of LDs is out of the scope. Thus, we will give details only about LEDs. The major difference between a LD and a LED is that, the former is a coherent light source and other is an incoherent source. That is, in the LED structure photons are emitted spontaneously with different phases. However, with LDs, a photon stimulates another photon that is radiated with a phase correlated with the previous which is called coherent radiation.

Basic Principles of LEDs
The idea behind the emission of light with a p-n type LED is that, a bias voltage is applied to the p-n junction and by this way, holes in the p-junction move towards the opposite side. Also, the electrons residing in the n-junction are induced towards the p-junction. These minority carriers recombine in the depletion layer which is also called band-gap. In order for a high-energy level electron to recombine with a lower-energy proton, it should release the excessive energy. That is, the electron passes from the conduction band to the valence band. This excessive energy is released as a photon and approximately equal to the band-gap energy. The magnitude of the energy of the photon determines its wavelength which can be adjusted by the type of the semiconductor material. Relation between the band-gap energy and the wavelength of the emitted photon is given as follows:

$$E_g = h * f \quad (1)$$

where h denotes the Planck's constant with the value equal to 6.626 × 10−34 Js and f expresses the frequency of the radiated photon.

$$h * f = h * (c / \lambda) \quad (2)$$

where c denotes the speed of light = $3 * 10^8$ m/s and λ is the wavelength of the emitted photon.

Efficiencies of LEDs
An ideal LED should emit a photon per an injected electron. The ratio of the number of photons emitted to the number of electrons injected is defined as the internal quantum efficiency and represented in

$$\eta_{int} = n_{p\text{-}emt} / n_{e\text{-}inj} \quad (3)$$

where η_{int}, $n_{p\text{-}emt}$ and $n_{p\text{-}emt}$ denote the internal quantum efficiency, number of protons radiated from the active region and number of electrons injected respectively.
In an ideal LED, all of the photons in the active region, should leave te diode, which is called the unit extraction efficiency. However, not all of the photons emitted in the active region, leave the diode due to several reasons such as absorption, etc. So-called the extraction efficiency is another important parameter defining the efficiency of a LED. That is the ratio of the number of photons radiated into the free space per second to the number photons emitted in the active region per second and represented in Eq.(4).

$$\eta_{extract} = n_{p\text{-}emt\text{-}air} / n_{p\text{-}emt} \quad (4)$$

where $\eta_{extract}$, $n_{p\text{-}emt\text{-}air}$ and $n_{p\text{-}emt}$ represent the extraction efficiency, number of photons emitted into the air and number of photons radiated in the active region respectively.
Consequently, we can derive the external quantum efficieny of a LED by combining the Equations (3-4):

$$\eta_{ext} = n_{p\text{-}emt\text{-}air} / n_{e\text{-}inj} \quad (5)$$

Ultimately, the power efficiency of a device is the ratio of the output power to the ratio of the input power, that is the electrical power applied to the LED (P_{inj_elec} = V * I) to the emitted photon energy (P_{photon}).

$$\eta_{pow} = P_{photon} / (V * I) \quad (6)$$

Radiation Pattern of LEDs
A LED comprises of a semiconductor light source and a surrounding material with different refracting indexes respectively. The most popular LEDs are the ones with planar surfaces of which the emission pattern is modeled with Lambertian Law. Although alternative surface shapes such as hemsipehere or parabolic are possible, fabrication of these LEDs are much more complicated. Light emerging from the semiconductor light source, faces with the surrounding material and refracts into the air with an angle different from the incoming one which can be explained by the Snell Law (Figure 3):

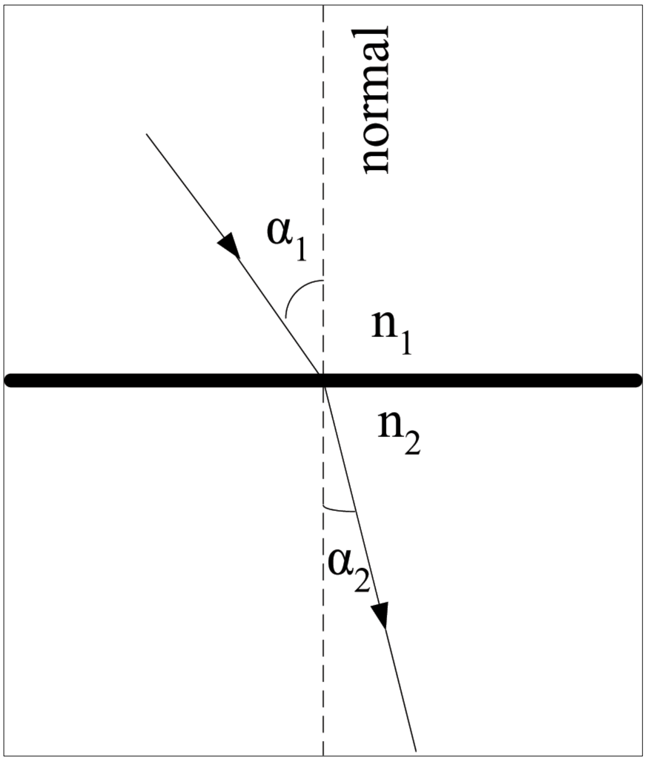

Fig 3: Refraction of a signal during the transition between two different materials with different refraction indices.

Conclusion
An alternative solution proposed for this first-meter bottleneck problem is shifting the working frequency interval to the unlicensed 60 GHz band. By this way, it is desired to widen the band with and achieve higher data rates. Regarding to these quests, it is desired to utilize the mm-length electromagnetic waves (λ <= 1mm, f > 100 GHz) with the aim of enabling supplementary communication channels. In recent years, one of the ideas put forward for wireless optical communication is the visible light communication method. It is possible to achieve illumination and data transfer simultaneously by means of LEDs that is the prominent lighting equipment lately. By this way, both interior lighting of a room and data transfer will be achieved without the need of an additional communication system.

References

1. http://www.wi-fi.org/news-events/newsroom/wi-fi-alliance-and-wireless-gigabit-alliance -to-unify
2. http://www.wi−fi.org/download.php?file=/sitesi/default/files/private/Wigig_White_ Paper_20130909.pdf
3. https://gigaom.com/2009/05/06/wigig-alliance-to-push-6-gbps-wireless-in-the-home/
4. Stallings W. Wireless Communications and Networks, NJ: Pearson Prentice Hall, 2005.
5. O'Brien DC, Katz M. Short-Range Optical Wireless Communications, Wireless World Research Forum (WWRF) White Papers, 2005.
6. Barry R. Wireless Infrared Communications, Boston: Kluwer Academic Publishers, 1994.
7. Ramirez-Iniguez R, Idrus SM, Sun Z. Optical Wireless Communications: IR for Wireless Connectivity, Boca Raton: CRC Press, 2008.
8. Ciaramella E, Arimoto Y, Contestabile G, Presi M, D'Errico A, Guarino V *et al*. 128 terabit/s (32 × 40 Gbit/s) WDM transmission system for free space optical communications, IEEE Journal on Selected Areas in Communications. 2009; 27:1639–1645.
9. Rajagopal S, Roberts RD. IEEE 802.15.7 Visible Light Communication: Modulation Schemes and Dimming Support, IEEE Communications Magazine, 2012, 72-83.
10. Ghassemblooy Z, Popoola W, Rajbhandari S. Optical Wireless Communications System and Channel Modelling with MATLAB, CRC Press Taylor & Francis Group, 2013.
11. Komine T, Tanaka Y, Haruyama S, Nakagawa M. Basic study on Visible-Light Communication using Light Emitting Diode Illumination, Proceedings of the 8 th International Symposium on Microwave and Optical Technology, Canada, 2011, 45-48.
12. Tanaka Y, Haruyama S, Nakagawa M. Wireless optical transmission with the White colored LED for the wireless home links", Proceedings of the 11th International Symposium on Personal, Indoor and Mobile Radio Communications, London, UK, 2000, 1325-1329.
13. Komine T, Nakagawa M. Integrated System of White LED Visible-Light Communication and Power-Line Communication, IEEE Transactions on Consumer Electronics. 2003; 49(1):71-79.
14. Tanaka Y, Komine T, Haruyama S, Nakagawa M. Indoor Visible Light Transmission System Utilizing White LED Lights, IEICE Transactions on Communications. 2003; 86(8):2440-2454.
15. Komine, Toshihiko, Nakagawa M. Fundamental Analysis for Visible-Light Communication System using LED Lights, IEEE Transactions on Consumer Electronics, 2004, 50(1).
16. Sklavos N, Hübner M, Goehringer, Kitsos P. System-Level Design Methodologies for Telecommunication, Springer, 2013.
17. Sze SM, Ng KK. Physics of Semiconductor Devices, 3rd ed Hoboken, New Jersey: John Wiley & Sons Inc., 2007.