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APPLICATION OF VISIBLE LIGHT COMMUNICATION (VLC) IN VARIOUS AREAS: SURVEY

Abstract. Optical wireless communication allows communication of ultraviolet, infrared, or visible light to carry a signal. Visible light communication (VLC) is a member of optical wireless communication that operates in visible band from 390 nm to 750 nm range. VLC uses light emitting diodes (LED) that is pulsed at very high speed. VLC is known as next potential communication tool that has made tremendous improvement in wireless communication technologies. Possible applications areas of VLC are underwater communication, Li-Fi, vehicle to vehicle communication, in-house applications, etc. use features of VLC that allows to make an attractive area of research. In this work, due to features that VLC offers, possible application areas are presented and discussed.

Keywords: VLC, Li-Fi, vehicle to vehicle communication, access control system, in-house application.

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Аңдатпа. Оптикалық сымсыз байланыс ультракүлгін, инфрақызыл немесе көрінетін жарық арқылы сигнал жіберуге мүмкіндік береді. Көрінетін жарықпен байланыс (VLC) - 390 нм-ден 750 нм-ге дейінгі көрінетін диапазонда жұмыс істейтін оптикалық сымсыз байланыс бөлігі. VLC өте жоғары жылдамдықпен импульс беретін жарық диодтарын (LED) пайдаланады. VLC сымсыз байланыс технологиясын едәуір жақсартқан келесі ықтимал байланыс құралы ретінде белгілі. VLC-дің ықтимал қосымшалары-су асты байланысы, Li-Fi, көлік құралдары арасындағы байланыс, Ішкі қосымшалар және т. б. зерттеу саласын тартымды етуге мүмкіндік беретін VLC мүмкіндіктерін пайдаланыңыз. Бұл жұмыста VLC ұсынатын мүмкіндіктердің арқасында мүмкін болатын қосымшалар ұсынылады және талқыланады.

Түйін сөздер: VLC, Li-Fi, көлік құралдары арасындағы байланыс, қол жеткізуді басқару жүйесі, ішкі бағдарлама.

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Аннотация. Оптическая беспроводная связь позволяет передавать сигнал с помощью ультрафиолетового, инфракрасного или видимого света. Связь с видимым светом (VLC) является частью оптической беспроводной связи, которая работает в видимом диапазоне от 390 нм до 750 нм. VLC

использует светодиоды (LED), которые пульсируют с очень высокой скоростью. VLC известен как следующий потенциальный инструмент связи, который значительно улучшил технологии беспроводной связи. Возможными областями применения VLC являются подводная связь, Li-Fi, связь между транспортными средствами, внутренние приложения и т.д. используйте возможности VLC, что позволяет сделать привлекательной область исследований. В этой работе, благодаря функциям, которые предлагает VLC, представлены и обсуждены возможные области применения.

Ключевые слова: VLC, Li-Fi, связь между транспортными средствами, система контроля доступа, внутреннее приложение.

Introduction

Visible light communication (VLC) is a subset of optical wireless communication technologies that uses visible light for data communication. Fluorescent lamps and light emitting diodes (LED) are both can be used in a visible spectrum offering different amounts of signals over short distances. Signal transmission rate for using LED is up to 500 Mbit/s whereas for fluorescent lamps rate is 10 kbit/s. LED and photodiode take main role during communication. LED is used as a transmitter or source. Photodiode is a receiver, and devices that contain a photodiode receive signal from light sources. VLC offers high speed internet access initially in the indoor environment.

Radio Frequency (RF) communication is widely used in many areas. However, discovery of VLC decreases usage of RF signals that also used for same purposes. Compared to RF communication VLC uses less power consumption and it is power efficient system. Bandwidth of VLC is higher than RF. Frequency range for VLC is from 430 THz to 790 THz, and for RF this property is from 3 KHz to 300 MHz. RF communication is harmful when high power is used for transmission. Fortunately, there is no health risk involved in VLC. One benefit of RF communication is it is not visible, and no light is required. But its installation is harder than VLC and it depends on indoor/outdoor applications [1]. VLC is good for short range and indoor applications, but RF is ideal for long distance and both indoor and outdoor applications.

According to the recent forecasts, it is expected that mobile data traffic will grow with an aggregate annual growth rate of 47% between 2016 and 2021 [2]. Taking into consideration of the high congestion of the radio spectrum, an additional solution is necessary, and VLC is one of the potential candidates to provide complementary spectrum. Many researches are being done for increasing conventional approaches of VLC. For instance, researches in Pi-Lab is concentrated on extending the data rates supported by LED infrastructure developing polymer LEDs [2].

The main characteristics of VLC like low power consumption, no health hazard, high bandwidth and unlicensed channels allows to its implementation in

many applications including Li-Fi, WLAN, underwater communication, vehicle to vehicle communication, hospitals, etc. In this work, various types of applications in different area that are based on VLC are described and discussed.

Applications of VLC

Applications of visible light communication are found in many fields. These applications use visible light for communication to afford strong security and high-speed internet in a short range. Potential applications are discussed in this section.

Li-Fi

Li-Fi is a visible light communication system (VLC) that uses light to send wireless data embedded in its beam. A Li-Fi enabled device converts a beam of light into an electrical signal. Then the signal is converted back to data. This term was coined by German physicist Harald Haas during TED Talk in 2011. He foresaw the idea of using light bulbs as wireless routers [3]. Benefits of using Li-Fi is its data density is reduced, and there is no interference. Unlike Wi-Fi, speed of internet in Li-Fi is higher. Due to its impressive speed, Li-Fi can have a huge impact on the Internet of things. Given that data is transmitted at a much higher level, even more devices connected to the Internet will be able to communicate with each other [4]. Considering unavailability of travelling light through walls, Li-Fi signal is secure in a physical space. Li-Fi has a smaller range than Wi-Fi, and therefore it is safer in this regard. Although this parameter can be taken into account as its disadvantage, it is worth noting that from the point of view of the security of data transmission, a shorter range can also be considered as a positive side. This can be very useful in industries that process a large amount of confidential data, for example, in healthcare [4]. The company, founded by Professor Herald Haas in 2012, known as pureLifi, conducts experiments and actively explores achievements in this field [3]. Startup Velmenni, is at the forefront of this technological revolution in India [5]. All sources of research say this technology has the potential to become ubiquitous.

Vehicle to vehicle communication

Vehicle to vehicle (V2V) communication uses wireless network to exchange information between vehicles about them using sensors and dedicated short-range radio communication (DSRC) devices [6]. The information consists speed, direction, braking status, location and loss of stability. Unlike ultrasonic sensors, radars, and cameras, capability range of V2V communication is longer (300 meters). Applications of V2V communication informs about dangerous situations earlier and more effectively. In the hybrid VLC/RF system, vehicle lights and traffic light infrastructure is used for the interest of VCL communication and radio frequency as shown in Figure 1 [7]. VLC can reach reliably to the information that vehicles disperse with low latency. Li-Fi can be used in order to work with extremely low latency in safety communication of vehicles [8].

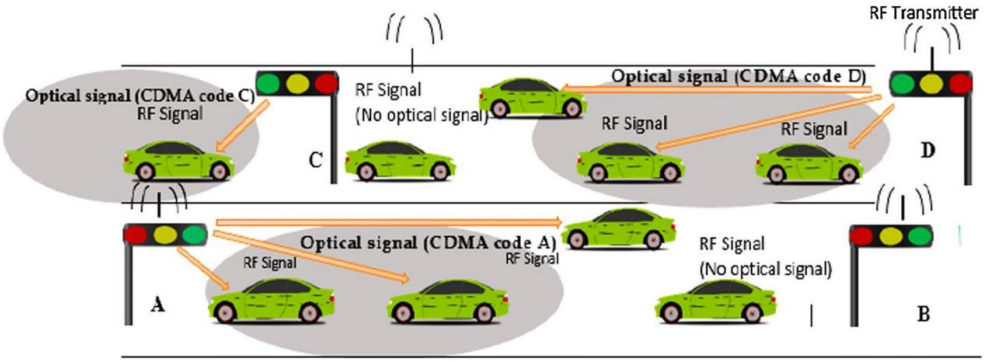

Figure 1. Hybrid VLC/RF system

In-house applications

VLC gives benefits of using in indoor applications. Poves et al. [9] presented a remote access application using VLC. The application provides wireless access to remote computers. Tablet interface communicated with X display manager via XDMCP with computer that allows to transmit large amount of data over uplink and downlink. Another feature of the system is its availability to combine with multiuser and low-cost scalability. The authors also suggest that this kind of system also can be used in hospitals or avionics, where EMI problem is minimized. In hospitals patients are monitored by systems using OCDMA technique and several low-rate sensors.

Access control system

In terms of security needs VLC offers high security level, thus data range is short and the data can be accessed only in visible light area. Xue et al. [10] proposed access control system joined with VLC to design Hamming-encoded VLC access control system. The system consists of an optical key terminal and access control terminal. The optical key terminal sends information that is received by access control terminal. User's identity information is stored in a chip of optical key terminal, and password information verifies passed through the access control. The access control receives visible light and records information such as frequency and time. After that access control checks correctness of the information inn database. If the key is right, then the access control alarms. Hamming code analyzes the performance of the system. The results show that Hamming code effectively reduces the error rate of the system. Further work improves the security level and increases the cost of cracking.

Latif Ullah Khan discussed other area where VLC benefits and can be applied [11]. Other than Li-Fi and V2V communication, VLC can be useful in underwater communication, hospitals, information displaying signboards, visible light ID system, sound communication system, wireless local area network, etc. In hospitals VLC decreases safety issues replacing radio frequency in electromagnetic wave sensitive areas which is harmful for human body [12]. Visible light ID system identifies in which room and certain building the user is

located [11]. In transmission of music signals RGB LEDs are used [13]. When setting up local area network (LAN) LED based VLC is can be used [14]. Ineffectiveness of radio frequency waves underwater can be changed by VLC communication where data transmission is done effectively [15].

Conclusion

Visible light communication has a high bandwidth, it is not hazardous to health of human body, creates high level of security, and in electromagnetic areas it has no interference with radio waves. These s features made VLC an attractive technique for the next level of communication. Compared to analogue Wi-Fi that radio frequency, Li-Fi is several times faster (250 times faster in some references). VLC's potential application areas such as security system, access control systems, hospitals, Li-Fi, traffic communication systems, vehicle to vehicle communication, and underwater communication have made visible light communication an attractive area of research.

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