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Visible Light Communication: Importance and Thai Preparations

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Abstract

Since the Internet of Thing allows devices to be interconnected across communication networks, the demand for bandwidth in personal communication are growing rapidly as the number of devices increases. Moreover, the location estimation in an indoor environment requires a proper technology because the global positioning system cannot provide satisfactory accuracy. Thus, a visible light communication (VLC) technology is introduced so as to add extra capacity to an existing radio frequency infrastructure. In practice, the VLC can utilize the lighting system infrastructure to transmit data via light intensity together with illumination. Several VLC standards have been published by the visible light communication consortium (VLCC) and the institute of electrical and electronics engineers (IEEE) in 2003 and 2011 respectively. In the past five years, many researchers in Thailand have focused on both VLC basic research and technology implementation. Additionally, the inter-University co-operation known as LED-SmartCon has also been established by ECTI Association to promote the VLC technology in Thailand.

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1. Introduction

Optical transmission has been used by ancient Greeks and Romans since approximately 800 BC. They used fire beacons for transmitting single bit information over a long distance between mountain tops. The transmission rate of optical transmission was increased by employing an optical telegraph invented by Claude Chappe in early 1790's. Almost a century later, the photophone was invented by Alexander Graham Bell. The voice signal was modulated with reflected light from the sun on a foil diaphragm. Since the pioneer work of F.R.Gfeller and G.Bapst in 1979,

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the optical transmission in the free-space infrared band has been extensively studied. Then, the open standard for IR data communications was published by the infrared data association (IrDA) in 1993. For visible light communication (VLC), two standards were published by the visible light communication consortium (VLCC)[1] and the institute of electrical and electronics engineers (IEEE)[2] in 2003 and 2011 respectively.

Since a demand for bandwidth in personal communication, i.e., mobile phone, computer, wearable device, and Internet of Thing, are growing rapidly as the number of users increases, an alternative communication technology is required to add extra capacity to an existing radiofrequency infrastructure. Radio frequency communication has some limitation when people carry more than one communication device at the same time, because each device needs high data rate. Furthermore, a location-specific service has recently been received more attention because the global positioning system (GPS) cannot provide satisfactory accuracy for estimating the location in both an indoor and an outdoor environments. Examples for indoor and outdoor environment services are location-specific multimedia contents, security messages, illuminated advertising boards, car-to-car communication, intelligent transport systems (ITS), and so forth.

Optical communication technology is the promising technology that could be used for addressing the congested spectrum bandwidth of radio frequency communication. The optical wireless communication that carries information by modulating light around 400 – 700 nm is called VLC. The VLC system can utilize the existing lighting system infrastructure to transmit data along with illumination, which can be achieved by employing LED lights to send data via light intensity.

2. VLC System

A typical indoor VLC system is illustrated in Fig.1. The LED lamps are installed on the ceiling for illuminating all areas in a building, including rooms and corridors. One of the lamps is functioned as a coordinator to transmit visible light beacon or data frame, e.g., computer data, serial number, product information, or location information, through all LED lamps. Thus, the receiver or VLC end device can obtain information from the coordinator device via light intensity. The information may include additional data, e.g., product name, product specification, or the location where the lamp is installed. The up-link from a VLC end device to a coordinator device could be on a modulated retro reflector[3], transmitting VLC in the dark[4], or existing RF or IrDA link. A modulated retro reflector controls the amplitude of the incident light from the LED transmitter before reflecting back to the coordinator. In the case of VLC in the dark, the duty cycle of the LED light is reduced in order to produce a very narrow pulse width such that the lamp appears dark while the receiver at the coordinator device can still detect the transmitted signal.

In addition, Fig. 2 shows an outdoor VLC system, which can provide connectivity between car and road infrastructure, e.g., car's head light and rear light, traffic light, or illuminated advertising board so as to exchange information among all devices in the intelligent transport systems.

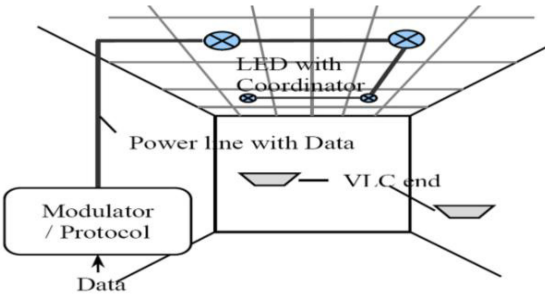

Fig 1: An example of an indoor VLC system

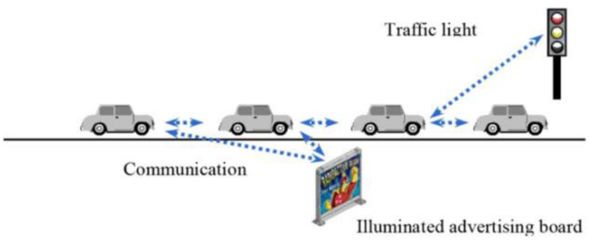

Fig 2: An example of an outdoor VLC system

Applications on VLC can be classified into four groups, based on indoor/outdoor with low/high bit rate. An example of an indoor/low bit rate group is the infrastructure with fixed lamp location to enable identification broadcasting or location information, whereas that of an indoor/high bit rate group is a data communication via a mobile device, which uses battery as a power supply; therefore, it can transmit data only for a short distance. On the other hand, an example of outdoor/low bit rate group is a car to car communication or car to road infrastructure communication that has moderate power supply and intense light source for using long range communication, while