Abstract

Looking beyond conventional wireless networks, **VLC** holds significant potential to revolutionize the way we perceive data transmission. Moreover, the lighting industry is undergoing a transformation towards a 'light-as-a-service' (LaaS) business model, where lighting infrastructure is repurposed into a wireless communication network. This transformation can enable **VLC** systems to access a frequency spectrum 1000 times larger, facilitating greater cell densification in the future communication and lighting landscape. Both **VLC** and its networked counterpart are expected to play a crucial role in the evolution of data transmission, especially in the context of upcoming 6G networks, the Internet of Everything, and Industry 4.0 applications. The central theme of the thesis revolves around the design, modeling, and assessment of indoor **VLC** Systems. The aim is to overcome the shortcomings observed in current indoor **VLC** system designs, particularly from a lighting perspective. This work seeks to provide constructive solutions that enable the harmonious integration of communication and illumination, fostering improved joint performance in these aspects.

The initial phase of the research focuses on exploring the interferences arising from artificial ambient light sources and their integration with natural daylight in indoor environments. In indoor environment, all the light sources may not always used for both communication and illumination purposes. Also there is a need for dimming to make the system energy efficient as per the available daylight. This study introduces a forward error-corrected receiver configuration capable of effectively mitigating the impact of ambient light interferences. The proposed methodology involves employing a Tail Biting convolution encoder in the transmitter's encoding section and a Viterbi decoder in the receiver's decoding section to enhance bit error rate performance. Additionally, this research segment presents a stand-alone prototype for **VLC** that integrates daylight and supports dimming. The proposed system exhibits a remarkable energy-saving capability, reaching up to 37.29% under maximum daylight conditions. The investigation extends to assessing the performance of both illumination and communication under varying daylight conditions. Furthermore, the short-term Flicker Severity Index is experimentally evaluated and compared against the threshold level specified by the International Electrotechnical Commission.

The next phase of this research focuses on designing an indoor multi-cell **VLC** system, which is crucial for utilizing the collective channel capacity from multiple optical sources /APs concurrently. Within the framework of indoor **VLC** multi-cell operation,

CCI emerges as a major challenge when signals from one AP interfere with those from neighboring APs. The extent of this interference is closely tied to the distribution and HPBW of the installed APs. Moreover, the receiver structure and FOV play crucial roles in controlling **CCI**, as they can significantly degrade **SINR** performance. The primary objective of this segment is to analyze the impact of different transmitter configurations and receiver FOVs, considering a simple PD receiver. A design-centric methodology, based on multiple criteria decision modeling (MCDM), is proposed to determine the optimal transmitter configuration and receiver FOV under lighting constraints. This optimal selection ensures improved **SINR** performance with a simple PD receiver. Additionally, a hemispheric angle diversity receiver (HADR) structure is adopted to enhance both lighting and communication performances. It has been demonstrated that the optimal design of HADR not only improves the average **SINR** value across the CF but also reduces spatial fluctuations, resulting in a significantly high consistency factor.

In the final segment of this thesis, the focus shifts towards designing a heterogeneous **Li-Fi** network. This endeavor aims to tackle practical challenges stemming from light path blockages and user mobility. With regard to multi-user association, this segment also imparts the motivation behind the adoption of an improved version of ADR (called FDR) in a hybrid **Li-Fi** Wi-Fi network (HLWNet). Based on different mobility scenarios and blockage conditions the performance of the proposed HLWNet has been evaluated. A **Li-Fi** channel model with FDR and a rule-based resource allocation algorithm (RBRA) has also been proposed for the purpose. Nevertheless, the network data quality of the multi-user system has been estimated in terms of packet loss, latency, and fairness index.

The customizations and contributions outlined in various stages of this research are pivotal for the future adaptation of this eco-friendly technology in indoor environments. As communication and lighting industries increasingly prioritize this green technology and intertwine their efforts, the insights and innovations from this research will prove fruitful in driving the commercial success of **VLC** and **Li-Fi**.

19-06-2024