UNIVERSITI TEKNOLOGI MARA

MODELLING AND CHARACTERISATION OF THE IEEE 802.15.7 MEDIUM ACCESS CONTROL LAYER (MAC) FOR INDOOR VISIBLE LIGHT COMMUNICATION (VLC)

ANUAR BIN MUSA

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ABSTRACT

Radio Frequency (RF) technologies are presently the main medium for wireless communication systems. However, like many other technologies, RF has constraints such as limited bandwidth and electromagnetic interference which limit the applications of RF technologies in certain scenarios. For example, RF signals can cause interference with aircraft communication systems, medical equipment and devices in the hospital or navigational devices in airports. Meanwhile, current advancements in Light Emitting Diode (LED) devices and materials are driving the applications of Visible Light Communication (VLC). VLC combines both illumination and communication together within one device. VLC uses a white light LED as a source for the data transmission. Many opportunities exist to exploit the low-cost nature of LEDs and their lighting properties for widespread deployment of VLC. However, some characteristics of the optical wireless medium, including mobility, directionality, multi-user access and susceptibility to ambient light noise sources, must be managed and overcome. VLC system is standardised by IEEE 802.15.7 specification. In this dissertation, an analytical model and the ns-2 simulation model of the indoor Visible Light Communication (VLC) is developed and analysed bas)ed on the IEEE 802.15.7 standard. The analytical model is developed based on the Discrete Time Markov Chain (DTMC) method. The analytical model is compared with the theoretical CSMA model to verify the correctness of the proposed models. The throughput curves of the theoretical CSMA model, the DTMC analytical model, and the ns-2 simulation model follow the same pattern. The throughput improvement for the DTMC analytical model over the CSMA basic model at the maximum throughput value is ranged from 8 percent to 31 percent depending on the network configuration. The throughput improvement is due to the back-off mechanism implemented by the proposed IEEE 802.15.7 model. Thus, this verifies correctness and the improvement of the proposed DTMC analytical model. The detailed design and implementation of a VLC prototype for an indoor optical wireless communication is also presented based on an Optical Ethernet Transceiver previously developed by the TMR&D Advanced Internet Lighting Application (AILA) team. The VLC prototype consists of an Optical Ethernet Transceiver and the software VLC MAC that manages the connections for multiple users. The software VLC MAC is developed to support multi-user connectivity using the existing Optical Ethernet Transceiver. The throughput of the Software MAC VLC system is about 7.5 Mb/s for 1024 bytes packet size which is 21% lower compared to the maximum theoretical rate. This is due to the unused 0.33 part of the slot size for every packet sent, which can be translated to 16.5 % wastage of throughput. The remainder is due to the packet processing delay at the application layer. Thus, the soft MAC implementation result matches the maximum theoretical rate of the VLC system.

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CHAPTER ONE
INTRODUCTION

1.1 MOTIVATIONS

A Radio frequency (RF) communication system is a leading and growing technology that has been widely used and will continue to be the main medium for wireless communication in the foreseeable future. However, RF suffers from a number of limitations in certain scenarios, especially in restricted areas [1], [2] where the RF signals can cause interference with communication and other systems.

For the next generation of wireless communication technology, typically specified as the LTE/4G system, with the support of the advancement of Laser Diodes (LD) and Light-Emitting Diode (LED) materials, researchers believe that optical wireless communication (OWC) has potential and is a promising complementary technology to the RF communication system for access to networks and for short range indoor applications [3].

In general, OWC uses light beams that are transmitted through the air or space to carry information. The usage of OWC can be traced back to ancient times when people used fire as a signal for long range communication such as warning of an invasion. In the modern era, Alexander Graham Bell patented a photophone [4] in June 1880 which used sunlight to carry voice over free space as illustrated in Figure 1.1. However, usage of the invention was not widespread due to the small transmission length and the sun does not constantly radiate light over a period of time [4], [5].