Improved power distribution in diffuse Indoor Optical Wireless systems employing multiple transmitter configurations

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Received 23 December 2005; Accepted 13 September 2006

Abstract. Power distribution plays a vital role in the performance of diffuse indoor optical wireless systems. Commonly used single-transmitter diffuse systems result in non-uniform power distribution patterns. We propose the use of multiple transmitters, suitably placed at different locations on the ceiling, as a technique to obtain fairly uniform power distribution on the floor. In this paper we use an extension of the recursive method developed by J.R. Barry and J.M. Kahn (IEEE Sel. Area Commun. 1 367, 1993), to compute multi-path impulse response and power distribution. We show that placement of the transmitters is crucial in achieving near uniform power distribution. Effect of the number of transmitters on power distribution and the channel bandwidth are also examined.

Key words: diffuse indoor infrared systems, indoor optical wireless channel, multi-transmitter indoor optical wireless systems

1. Introduction

Over the past decade the use of infrared (IR) frequencies for short range wireless communications has been explored by a good number of researchers (Gfeller and Bapest 1979; Barry and Kahn 1993; Carruthers and Kahn 1998; Kahn et al. 1998; Ghassemlooy and Boucouvalas 2005). Many potential applications for this technology have already been suggested. Among the several IR system configurations, the diffuse indoor optical wireless configuration (i.e. non-directed, non-line of sight) is one of the most convenient ones for local area networks (LAN) since it does not require careful alignment of the transmitter or the receiver, nor does it require a line-of-sight (LOS) path to be maintained. The other major advantages of diffuse systems are their flexibility and the roaming they allow in a room. This flexibility makes them the ideal choices for ad hoc networks. However, infrared links are affected by ambient light and can tolerate only comparatively limited path loss. Also, diffuse systems can incur a high optical path loss, which is typically 50–70 dB for a horizontal separation distance of 5 m
The path loss is further increased if a temporary obstruction, such as a person, obscures the receiver such that the main signal path is blocked, a situation referred to as shadowing. In addition, a photo-detector with a wide field-of-view (FOV) normally collects signals that have undergone one or more reflections from ceiling, walls and room objects. These factors necessitate the need for high optical power levels. However, indoor optical power levels have to be kept within the eye safety limits. Fig. 1 shows two diffuse IR trans-receiver configurations.

Generally a single transmitter (located on the center of the ceiling) is used to transmit power to the receivers located in the room. In such a system there will be substantial variation in the power levels at various points in the room, the maximum being at the center and the minimum levels at the far ends of the room. In our study, multiple transmitters were located on the ceiling and a single receiver on the room floor. Rays from the transmitters reach the receiver through direct rays and reflected rays from the ceiling and the walls. It is seen that the power levels on the floor vary drastically from place to place due to the multiple reflections from the walls and the ceiling. Many techniques have been suggested in literature to solve this non-uniform power distribution on the floor (Pakravan et al. 1996; Bakalidis et al. 1996; Carruthers and Kahn 1998; Kahn et al. 1998; Jivkova and Kavehrad 1999; Yang and Lu 2000). Among the above solutions the use of multiple transmitters is quite attractive since it provides a means of achieving near-uniform power distribution without much complexity. Such an approach can satisfy the eye safety standards and also mitigate the shadowing effect.

The received power level at a point can be computed from the impulse response of the channel. Some of the existing algorithms used to compute the impulse response are the recursive method (Barry and Kahn 1993), statistical approach (Perez-Jimenez et al. 1997), DUSTIN algorithm (Lopez-Hrnandez and Betancor 1997), Monte Carlo calculation (Perez-Jimenez et al. 1998a), modified Monte Carlo scheme (Perez-Jimenez et al. 1998b)