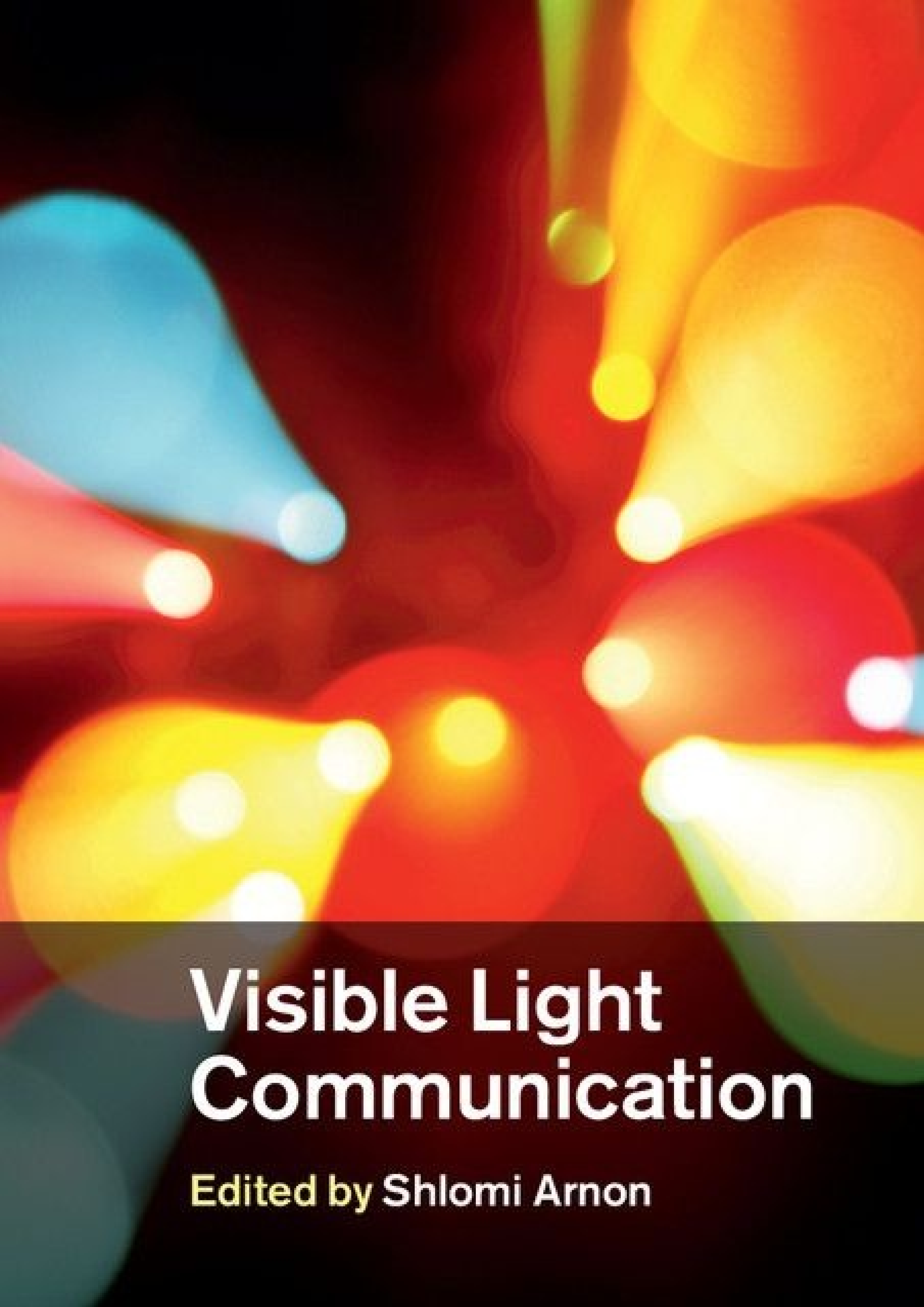

Visible Light Communication

Edited by Shlomi Arnon

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Visible light communication (VLC) is an evolving communication technology for short-range applications. Exploiting recent advances in the development of high-power visible-light-emitting LEDs, VLC offers an energy-efficient, clean alternative to RF technology, enabling the development of optical wireless communication systems that make use of existing lighting infrastructure.

Drawing on the expertise of leading researchers from across the world, this concise book sets out the theoretical principles of VLC, and outlines key applications of this cutting-edge technology. Providing insight into modulation techniques, positioning and communication, synchronization, and industry standards, as well as techniques for improving network performance, this is an invaluable resource for graduate students and researchers in the fields of visible light communication and optical wireless communication, and for industrial practitioners in the field of telecommunications.

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1 Introduction

Shlomi Arnon

Visible light communications (VLC) is the name given to an optical wireless communication system that carries information by modulating light in the visible spectrum (400–700 nm) that is principally used for illumination [1–3]. The communications signal is encoded on top of the illumination light. Interest in VLC has grown rapidly with the growth of high power light emitting diodes (LEDs) in the visible spectrum. The motivation to use the illumination light for communication is to save energy by exploiting the illumination to carry information and, at the same time, to use technology that is "green" in comparison to radio frequency (RF) technology, while using the existing infrastructure of the lighting system. The necessity to develop an additional wireless communication technology is the result of the almost exponential growth in the demand for high-speed wireless connectivity. Emerging applications that use VLC include: a) indoor communication where it augments WiFi and cellular wireless communications [4] which follow the smart city concept [5]; b) communication wireless links for the internet of things (IOT) [6]; c) communication systems as part of intelligent transport systems (ITS) [7–14]; d) wireless communication systems in hospitals [15–17]; e) toys and theme park entertainment [18, 19]; and f) provision of dynamic advertising information through a smart phone camera [20].

VLC to augment WiFi and cellular wireless communication in indoor applications has become a necessity, with the result that many people carry more than one wireless device at any time, for example a smart phone, tablet, smart watch, and smart glasses and a wearable computer, and at the same time the required data rate from each device is growing exponentially. It is also becoming increasingly clear that in urban surroundings, human beings spend most of their time indoors, so the practicality of VLC technology is self-evident. It would be extremely easy to add extra capacity to existing infrastructure by installing a VLC system in offices or residential premises. In Fig. 1.1 we can see an example of a VLC network that provides wireless communication to a laptop, smart phone, TV, and wearable computer.

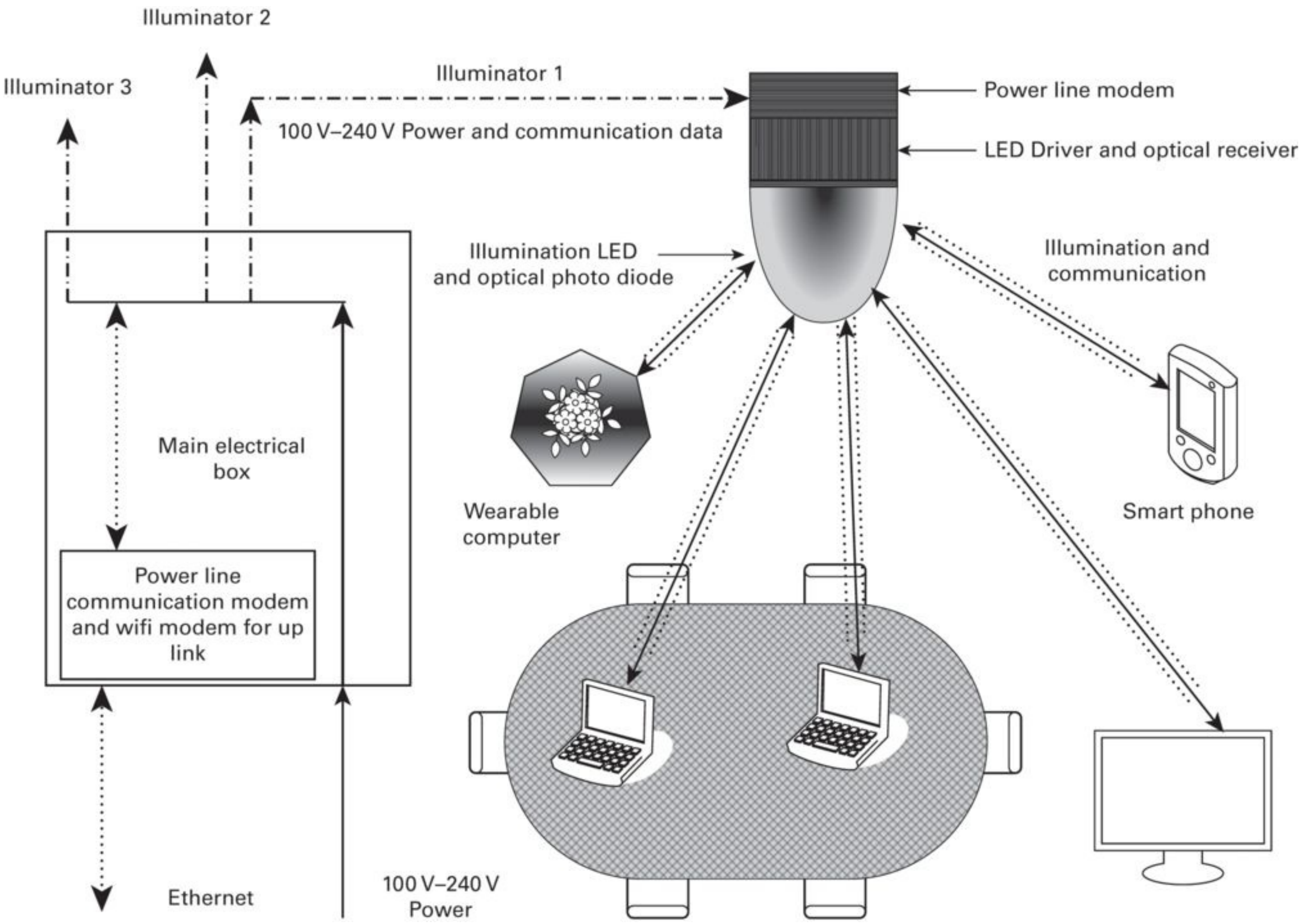

Figure 1.1 VLC wireless network.

The downlink includes illumination LED, Ethernet power line communication (PLC) modem, and LED driver, which receives a signal by a dedicated or dongle receiver as part of the device. The uplink configuration could be based for example on: a) a WiFi link; b) an infrared–IRDA link; or c) a modulated retro reflector (Fig. 1.2). A modulated retro reflector is an optical device that retro reflects incident light [21, 22]. The amplitude of the retro reflected light is controlled by an electronic signal, as a result modulation of the light can be achieved. In the cases of an infrared–IRDA [23] link or a modulated retro reflector the receiver could be part of the illumination LED. In that case the uplink receiver includes photo diode, trans impedance amplifier and modem. In this way, an operational wireless network could be created in next to no time.

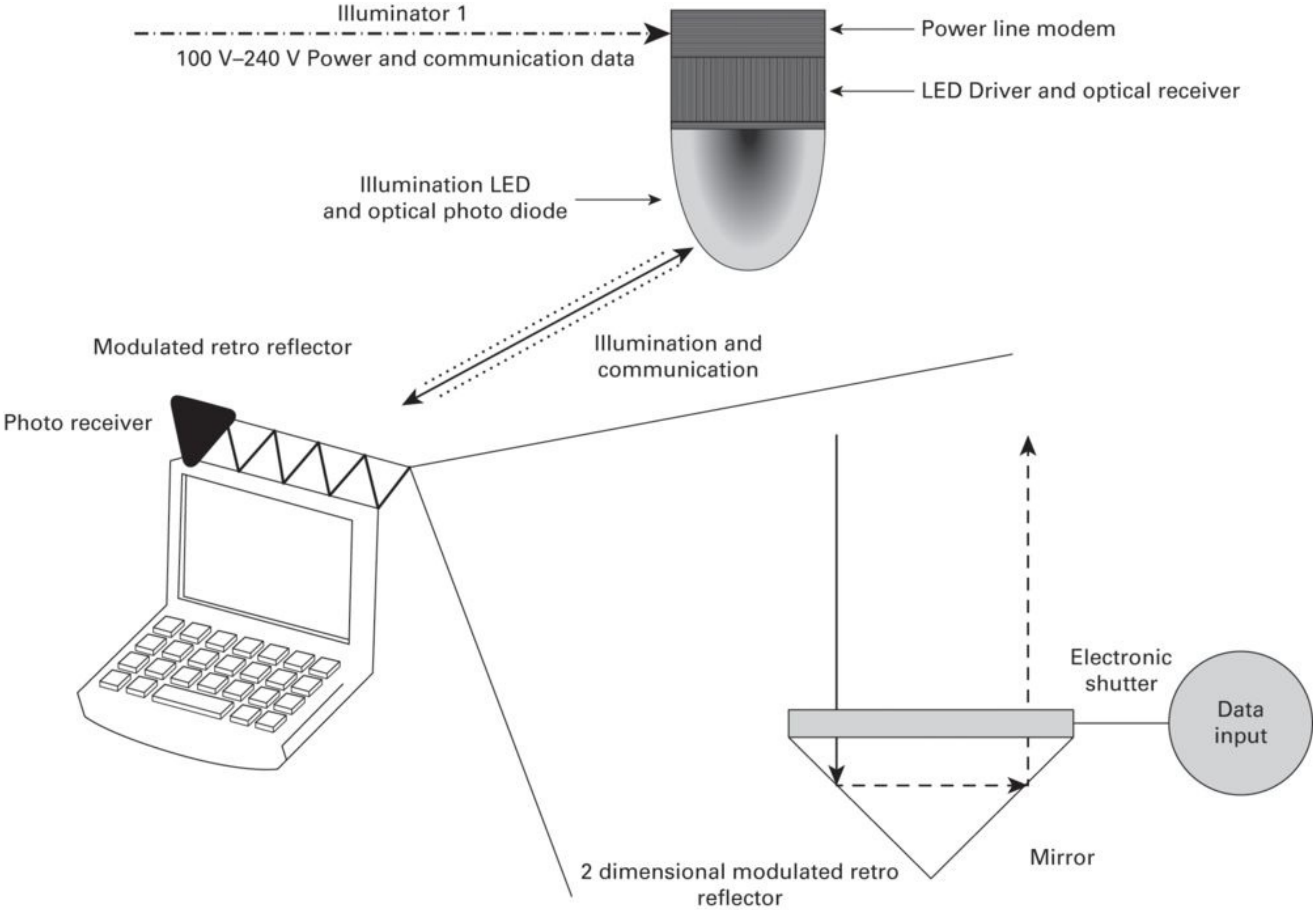

Figure 1.2 A wireless communication network based on modulated retro reflector.

In the near future, billions of appliances, sensors and instruments will have wireless connectivity, as can be anticipated from the revolutionary concept of the internet of things (IOT). This technology makes it possible to have ambient intelligence and autonomous control which could adapt the environment to the requirements and the desires of people. VLC could be a very relevant wireless communication technology that is cheap, simple and immediate and does not encroach on an already crowded part of the electromagnetic spectrum.

Intelligent transport systems (ITS) are an emerging technology for increasing road safety and reducing the number of road casualties as well as for improving traffic efficiency (Fig. 1.3). VLC have been proposed as a means for providing inter-vehicular communication and for establishing connectivity between vehicular and road infrastructure, such as traffic lights and billboards. These systems provide one-way or two-way short- to medium-range wireless communication links that are specifically designed for the automotive sphere. The technology uses the headlights and the rear lights of cars as transmitters, and cameras and detectors as the receivers. The traffic lights are the counterpart of a transmitter in this sphere.

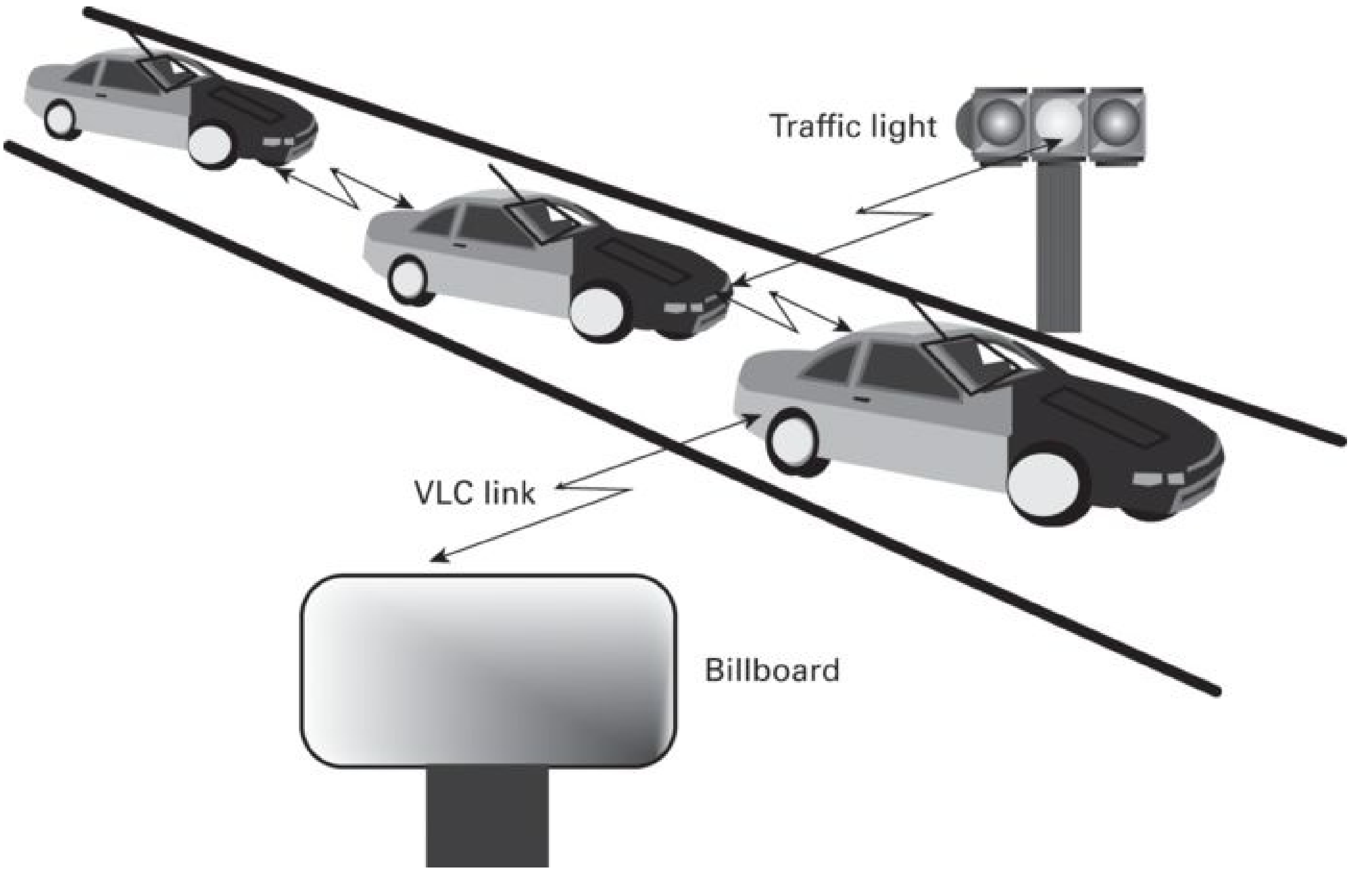

Figure 1.3 An intelligent transport system using VLC.

The medical community pursues ways to improve the efficiency of hospitals and at the same time to reduce hospital-acquired infections, which are very costly in money and human life. One way to upgrade the communication infrastructure is by wireless technology. The technology makes it possible for doctors to access and update patient data using tablet computers at the patient's bedside instead of manually keeping paper documents that are kept either at the bedside or in the nurses' back office station. Another application is a device used to monitor patient well-being and vital data remotely. Due to the fact that RF, like WiFi and cellular, is a best effort technology, meaning that the transmission of information is not guaranteed, interference from nearby devices could jam the communication. This situation is unacceptable for medical applications and therefore a switch to VLC technology is self-evident. It is clear that VLC technology can provide localized solutions immune to interference and jamming for the medical domain.

The toys and theme park entertainment sector is a very interesting application that takes advantage of VLC technology due to two main characteristics (Fig. 1.4). The first characteristic is the ability to communicate by line of sight or semi line of sight, so the communication is localized to a specific volume. This makes it possible to provide location based information in the theme park so the audience will have a multi-dimensional and multi-sensory experience. The same concept could be used in the toys market to communicate between toys, using the already present LED. The second characteristic is the low cost required to implement the technology in toy and park entertainment. One example of a way to reduce the cost of toys is using the toy LED simultaneously as transmitter and photo diode receiver.