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1 Introduction

Optical communication is any form of telecommunication that uses light as the transmission medium. Having originated in ancient times in the form of beacon fires and smoke signals that convey a message, optical wireless communication (OWC) has evolved to a high-capacity complementary technology to radio frequency (RF) communication. OWC systems utilize wavelengths in the infrared (IR) spectrum for IR communication and the visible light spectrum for visible light communication (VLC). Because of the availability of a huge license-free spectrum of approximately 670 THz, OWC has the potential to provide wireless links with very high data rates. In this book, optical modulation schemes, as well as signal processing and networking techniques, are presented to maximize the throughput of optical wireless networks using off-the-shelf components.

1.1 History of OWC

Examples of OWC in the form of beacon fires and smoke signals to convey a message can be found in almost all cultures. Semaphore lines are the earliest form of technological application of OWC [1]. The French engineer Claude Chappe built the first optical telegraph network in 1792. His semaphore towers enabled the transmission of 196 information symbols encoded in the position of two arms connected by a crossbar. As another example of early OWC, the heliograph is a wireless solar telegraph that signals flashes of sunlight by pivoting a mirror or interrupting the beam with a shutter. After the invention of the Morse code in 1836, navy ships communicated by means of a signal lamp with on-shore lighthouses for navigation. In 1880, Alexander Graham Bell demonstrated the first implementation of a free-space optical (FSO) link in the form of the photophone [2]. By using a vibrating mirror at the transmitter and a crystalline selenium cells at the focal point of a parabolic receiver, Bell was able to modulate a voice message onto a light signal.

The recent advancements in OWC technology gained significant pace after the pioneering work of Gfeller and Bapst in 1979 [3]. They showed the potential of OWC for high-capacity in-house networks promising hundreds of THz bandwidth of electromagnetic spectrum in the optical domain. One branch of OWC is targeted at outdoor FSO links over long distances which are generally realized through highly directional laser diodes as transmitters [4]. At the receiver side, generally, a photodiode (PD) is

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employed. Another branch of OWC focuses on indoor mobile wireless networks, and it is realized through diffuse light emitting diodes (LEDs) as transmitters [3]. The first indoor OWC system was reported by Gfeller and Bapst in 1979 [3]. At a center wavelength of 950 nm in the IR spectrum, the system was capable of achieving 1 Mbps using on–off keying (OOK) modulation and diffuse radiation for a coverage of an office room. In 1996, Marsh and Kahn demonstrated an indoor diffuse OOK IR system with a data rate of 50 Mbps [5]. Later in 2000, Carruthers and Kahn presented a faster OOK IR system implementation with a data rate 70 Mbps and a potential of up to 100 Mbps [6]. Tanaka *et al.* first considered white LEDs to convey information in addition to serving the primary functionality of illumination in an indoor setup. In 2003, they presented a OOK VLC system setup with up to 400 Mbps data rate [7]. Afgani *et al.* [8, TridentCom, 2006] showed for the first time, using a proof-of-concept demonstrator, that the high crest factor in orthogonal frequency division multiplexing (OFDM), typically a disadvantage in RF communication, can be turned into an advantage for intensity modulation and direct detection (IM/DD). They implemented the direct-current-biased optical OFDM (DCO-OFDM) transmission scheme, which was later used by other research groups. Vucic *et al.* ascertained the potential of VLC systems with a demonstration of a 500 Mbps data rate [9]. Their implementation was based on DCO-OFDM with bit and power loading and symmetric signal clipping. By separate modulation of the red, green, and blue (RGB) modes of an RGB white LED in a wavelength division multiplexing (WDM) fashion and by employing respective optical filters at the receiver, they have also been able to demonstrate 800 Mbps of a single RGB LED luminary [10]. By the use of a similar DCO-OFDM setup with a larger modulation bandwidth, Khalid *et al.* presented a link implementation that can achieve 1 Gbps with a single phosphor-coated white LED [11]. Later, they also demonstrated a 3.4 Gbps link with an off-the-shelf RGB LED [12]. Another similar gigabit/s OWC system with phosphor-coated white LED has been demonstrated by Azhar *et al.* using a 4×4 multiple-input–multiple-output (MIMO) configuration [13]. Recently, Tsonev *et al.* reported a data rate of 3.5 Gbps from a single-color micro LED in a single-input–single-output (SISO) setting [14, 15]. The fundamentals of optical modulation and signal processing that enable the aforementioned data rates are presented in this book alongside state-of-the-art networking concepts [16–18]. These developments promote OWC to an emerging wireless networking technology – light fidelity (Li-Fi), a term coined by Harald Haas at TEDGlobal in 2011 [19].

Originally targeted at the near infrared (NIR) spectrum [3, 20–22], the optical wireless link was meant for short-range communications. Since 1993, a standardized set of protocols of the Infrared Data Association (IrDA) [23] have been implemented for wireless infrared communication in portable devices, such as mobile phones, laptops, cameras, remote controls, and many more. With the advancements of solid-state lighting technology in recent years, LEDs are replacing incandescent light bulbs because of their reliability and higher energy efficiency, e.g. 5% vs. 30% in favor of LEDs [24]. In addition to illumination, LEDs are also envisioned to provide high-capacity wireless data broadcast [25–33]. Standardization of VLC research is strongly supported by the Visible Light Communications Consortium (VLCC) in Japan [34]. In 2011, the Institute

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of Electrical and Electronics Engineers (IEEE) published a standard for VLC, IEEE 802.15.7 – 2011, "IEEE Standard for Local and Metropolitan Area Networks, Part 15.7: Short-Range Wireless Optical Communication Using Visible Light" [35].

1.2 Advantages of OWC

In the last two decades, unprecedented spread of wireless communication systems has been witnessed. While at the beginning these systems were only able to provide voice service and some rudimentary data services, they have now matured to high-speed packet data networks which allow Internet browsing at the same speed as is achieved with fixed line connections [36]. However, there is still the need to increase data throughput and, consequently, data rates [37].

With the increasing popularity of smartphones, the wireless data traffic of mobile devices is growing exponentially. There have been many independent warnings of a looming "RF spectrum crisis" [38] as mobile data demands continue to increase, while the network spectral efficiency saturates despite newly introduced standards and great technological advancements in the field. By 2015, it is expected that total wireless data traffic will reach 6 exabytes per month, potentially creating a 97% gap between the traffic demand per device and the available data rate per device in the mobile networks [39]. In addition, it is estimated that by 2017 more than 11 exabytes of data traffic will have to be transferred through mobile networks every month [40]. Recently, the Wireless Gigabit Alliance has proposed the utilization of the mm-waves in the license-free 60 GHz band, where the availability of 7 GHz bandwidth enables 7 Gbps short-range wireless links [41]. The 60 GHz band has also been considered as a part of the IEEE 802.11ad framework for very high throughput data links in wireless local area networks (WLANs) using MIMO techniques [42]. However, due to the high path loss of the radio waves in this spectrum range, 60 GHz links are highly directional, and, therefore, require sophisticated digital beamforming and tracking algorithms for application in mobile wireless networks.

Since the RF spectrum is limited and expensive, new and complementary wireless transmission techniques are currently being explored that can relieve the spectrum utilization. One such promising emerging alternative approach is OWC, which offers many advantages over RF transmission. Most recently, VLC has been identified as a potential solution for mitigating the looming RF spectrum crisis. VLC is particularly enticing as lighting is a commodity that has been integrated into virtually every inhabited environment, and sophisticated infrastructures already exist. The use of the visible light spectrum for high-speed data communication is enabled by the emergence of the LED, which at the same time is at the heart of the next wave of energy-efficient illumination. In that sense, the concept of combining the functions of illumination and communication offers the potential for tremendous cost savings and carbon footprint reductions. First, the deployment of VLC access points (AP) becomes straightforward as the existing lighting infrastructure can be reused. Off-the-shelf technologies, such as power line communication (PLC) and power-over-Ethernet (PoE), are viable backhaul solutions

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for retrofit installations and new installations, respectively. Second, because lighting is on most of the time in indoor environments even during day time, the energy used for communication is significantly reduced as a result of the piggybacking of data on illumination. However, even if illumination is not required, energy-efficient IM/DD techniques exist that allow data communication, even if the lights are visually off [43]. These are already compelling benefits, but the case does not end there. In OWC, the signal can occupy license-free wavelengths in the visible light spectrum from 380 nm to 750 nm, and/or the NIR spectrum from 750 nm to 2.5 μm. The total available bandwidth resource amounts to approximately 670 THz, which is a factor of 10, 000 larger than the RF spectrum including the 60 GHz band. In addition to being a complementary non-interfering solution alongside the RF technology, OWC has the advantage of license-free operation over a huge spectrum resource. In addition, very high data rates can be realized by the use of low-cost front-ends with commercially available LEDs and PDs [20]. Furthermore, it is free of any health concerns as long as eye safety regulations are fulfilled [44]. This constraint is much less severe when using incoherent LEDs rather than laser diodes. With the advent of highly efficient high-power incoherent LEDs and highly sensitive PDs, OWC has become a viable candidate for medium-range indoor data transmission that can contribute to the cause of solving the spectrum deficit.

1.3 Application areas

OWC is generally realized in a line-of-sight (LOS) or a non-line-of-sight (NLOS) communication setup [20, 21]. LOS links can be generally employed in static communication scenarios such as indoor sensor networks, where a fixed position and alignment between the transmitter and receiver are maintained. In mobile environments such as commercial offices, mechanical or electronic beam steering [4] can be used to maintain an LOS connection. Such techniques, however, increase the cost of the optical front-ends. Therefore, in a mobile OWC network, where LOS links are likely to be blocked, transmission robustness can be facilitated through NLOS communication. Single-carrier pulse modulation techniques such as pulse width modulation (PWM), pulse interval modulation (PIM), pulse position modulation (PPM), and pulse amplitude modulation (PAM) experience inter-symbol interference (ISI) in the dispersive NLOS channel, and they therefore exhibit limited data rates unless computationally expensive equalizers are used [4, 20, 45]. Because of its inherent robustness to multipath fading, OFDM with multi-level quadrature amplitude modulation (M-QAM) is envisaged to enable NLOS communication, and therefore high-capacity wireless networking [8, 46, 47].

In addition, due to the fact that light does not propagate through opaque objects and walls, optical wireless signals can be confined within a room. This feature inherently eliminates concerns over the intercepting and eavesdropping of the transmission, resulting in secure indoor data links and networks. The same feature can be exploited to eliminate interference between neighboring cells. Furthermore, OWC is free of any health concerns as long as eye safety regulations are fulfilled [44]. Since optical radiation does not interfere with other electromagnetic waves or with the operation of

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sensitive electronic equipment, OWC enables safe data transmission in areas where RF communication and electromagnetic radiation are prohibited or refrained to avoid interference with critical systems. These include aviation, homeland security, hospitals, and healthcare, as well as petrochemical and nuclear power plants. Last but not least, radio waves are strongly attenuated in water, disallowing underwater RF transmission. However, since light propagates through water, OWC can be employed for underwater communication.

1.4 Li-Fi

To date, research in the field of OWC has been focused on successful implementations of physical-link connections and proofs of the concept [31]. For the realization of a mobile communication system, however, a full networking solution is required. This is what is referred to as Li-Fi: the networked, mobile, high-speed OWC solution [48]. The vision is that a Li-Fi wireless network would complement existing heterogeneous RF wireless networks, and would provide significant spectrum relief by allowing cellular and wireless fidelity (Wi-Fi) systems to off-load a significant portion of wireless data traffic.

1.4.1 Modulation

A seamless all-optical wireless network would require ubiquitous coverage provided by the optical front-end elements. This necessitates the usage of a large amount of Li-Fi enabled lighting units. The most likely candidates for front-end devices in VLC are incoherent LEDs for solid-state lighting because of their low cost. Due to the physical properties of these components, information can only be encoded in the intensity of the emitted light. As a result, VLC can be realized as an IM/DD system, which means that the modulation signal has to be both real-valued and unipolar non-negative. This limits the application of the well-researched and developed modulation schemes from the field of RF communications. Techniques such as PWM, PPM, OOK, and PAM can be applied in a relatively straightforward fashion. As the modulation speeds are increased, however, these particular modulation schemes begin to suffer from the undesired effects of ISI due to the frequency selective optical wireless channel. Hence, a more resilient technique such as OFDM is required. OFDM allows for adaptive bit and power loading of different frequency subbands according to the communication channel properties [49, 50]. This leads to optimal utilization of the available resources. Such channel conditions are introduced by the frequency response of an off-the-shelf LED which has a maximum 3-dB modulation bandwidth of a few tens of MHz [11, 12]. Further benefits of this modulation scheme include simple equalization with single-tap equalizers in the frequency domain, as well as the ability to avoid low-frequency distortion caused by flickering background radiation and the DC-wander effect in electrical circuits.

Conventional OFDM signals are complex-valued and bipolar in nature. Therefore, the standard RF OFDM technique has to be modified in order to become suitable for IM/DD

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systems. A straightforward way to obtain a real-valued OFDM signal is to impose a Hermitian symmetry constraint on the subcarriers in the frequency domain. However, the resulting time-domain signal is still bipolar. One way of obtaining a unipolar signal is to introduce a positive DC bias. The resulting unipolar modulation scheme is known as DCO-OFDM. The addition of the constant biasing level leads to a significant increase in electrical energy consumption. However, if the light sources are used for illumination at the same time, the light output as a result of the DC bias is not wasted as it is used to fulfill the illumination function. Only if illumination is not required, such as in the uplink of a Li-Fi system, the DC bias can significantly compromise energy efficiency. Therefore, researchers have devoted significant efforts to designing an OFDM-based modulation scheme which is purely unipolar. Some well-known solutions include: asymmetrically clipped optical OFDM (ACO-OFDM) [51], PAM discrete multi-tone (PAM-DMT) [52], flip-OFDM [53], unipolar OFDM (U-OFDM) [54], and spectrally factorized optical OFDM (SFO-OFDM) [55]. The general disadvantage of all these techniques is a 50% loss in spectral efficiency and data rates.

From a networking perspective, OFDM offers a straightforward multiple access implementation as subcarriers can be allocated to different users resulting in orthogonal frequency division multiple access (OFDMA). The merits of OFDM have already been recognized, and it is used in IEEE 802.11 Wi-Fi systems. Also, OFDMA is used in the 4th generation (4G) long-term evolution (LTE) standard for cellular mobile communications. Therefore, the application of OFDM in optical mobile networks would allow the use of the already established higher level communication protocols used in IEEE 802.11 and LTE.

1.4.2 Multiple access

A seamless all-optical networking solution can only be realized with a suitable multiple access scheme that allows multiple users to share the communication resources without any mutual cross-talk. Multiple access schemes used in RF communications can be adapted for OWC as long as the necessary modifications related to the IM/DD nature of the modulation signals are performed. OFDM comes with a natural extension for multiple access – OFDMA. Single-carrier modulation schemes such as PPM and PAM require an additional multiple access technique such as frequency division multiple access (FDMA), time division multiple access (TDMA), or code division multiple access (CDMA).

OFDMA has been compared with TDMA and CDMA in terms of the electrical power requirement in a flat fading channel with additive white Gaussian noise (AWGN) and a positive infinite linear dynamic range of the transmitter [56]. FDMA has not been considered due to its close similarity to OFDMA, and the fact that OWC does not use superheterodyning. In addition, due to the limited modulation bandwidth of the front-end elements, FDMA would not present an efficient use of the LED modulation bandwidth. CDMA demonstrates the highest electrical power requirement, since the use of unipolar signals creates significant ISI. TDMA is shown to marginally outperform OFDMA in this setup. The increased power requirement of OFDMA comes from

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the higher DC-bias level needed to condition the OFDM signal within the positive dynamic range of the LED. However, in a practical VLC scenario, where the functions of communication and illumination are combined, the difference in power consumption between OFDMA and TDMA would diminish as the excess DC-bias power would be used for illumination purposes. Furthermore, TDMA and CDMA systems experience low-frequency distortion noise due to DC wander in electrical components or flickering of background illumination sources, as well as severe ISI in the practical dispersive and frequency selective channel. Therefore, the design complexity of TDMA and CDMA systems increases as suitable techniques to deal with these issues need to be implemented.

In OWC, there exists an additional alternative dimension for achieving multiple access. This is the color of the LED, and the corresponding technique is wavelength division multiple access (WDMA). This scheme can reduce the complexity of signal processing at the expense of increased hardware complexity. This is because each AP would require multiple LEDs and PDs with narrow-band emission and detection spectra. Alternatively, narrow-band optical filters can be employed. However, the variation of the center wavelength generally results in variation of the modulation bandwidth, the optical emission efficiency of the LED, and the responsivity of the PD. This corresponds to a variation of the signal-to-noise ratio (SNR) and capacity in the different multiple access channels, which complicates the fair distribution of communication resources to multiple users.

1.4.3 Uplink

Until now, research has primarily focused on maximizing the transmission speeds over a single unidirectional link [11–13]. However, for a complete Li-Fi communication system, full duplex communication is required, i.e. an uplink connection from the mobile terminals to the optical AP has to be provided. Existing duplex techniques used in RF such as time division duplexing (TDD) and frequency division duplexing (FDD) can be considered, where the downlink and the uplink are separated by different time slots or different frequency bands, respectively. However, FDD is more difficult to realize due to the limited bandwidth of the front-end devices, and because superheterodyning is not used in IM/DD systems. TDD provides a viable option, but imposes precise timing and synchronization constraints similar to the ones needed for data decoding. However, TDD assumes that both the uplink and the downlink transmissions are performed over the same physical wavelength. This can often be impractical as visible light emitted by the user terminal may not be desirable [57]. Therefore, the most suitable duplex technique in Li-Fi is wavelength division duplexing (WDD), where the two communication channels are established over different electromagnetic wavelengths. Using IR transmission is one viable option for establishing an uplink communication channel [57]. A first commercially available full duplex Li-Fi modem using IR light for the uplink channel has recently been announced by pureLiFi [58]. There is also the option to use RF communication for the uplink [57]. In this configuration, Li-Fi can be used to off-load a large portion of data traffic from the RF network,

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thereby providing significant RF spectrum relief. This is particularly relevant since there is a traffic imbalance in favor of the downlink in current wireless communication systems.

1.4.4 The attocell

In the past, wireless cellular communication has significantly benefited from reducing the inter-site distance of cellular base stations. By reducing the cell size, network spectral efficiency has been increased by two orders of magnitude in the last 25 years. More recently, different cell layers composed of microcells, picocells, and femtocells have been introduced. These networks are referred to as heterogeneous networks [59, 60]. Femtocells are short-range, low transmission power, low-cost, plug-and-play base stations that are targeted at indoor deployment in order to enhance coverage. They use either cable Internet or broadband digital subscriber line (DSL) to backhaul to the core network of the operator. The deployment of femtocells increases the frequency reuse, and hence throughput per unit area within the system, since they usually share the same bandwidth with the macrocellular network. However, the uncoordinated and random deployment of small cells also causes additional inter- and intra-cell interference which imposes a limit on how dense these small base stations can be deployed before interference starts offsetting all frequency reuse gains.

The small cell concept, however, can easily be extended to VLC in order to overcome the high interference generated by the close reuse of radio frequency spectrum in heterogeneous networks. The optical AP is referred to as an attocell [61]. Since it operates in the optical spectrum, the optical attocell does not interfere with the macrocellular network. The optical attocell not only improves indoor coverage, but since it does not generate any additional interference, it is able to enhance the capacity of the RF wireless networks.

Li-Fi attocells allow for extremely dense bandwidth reuse due to the inherent properties of light waves. Studies on the deployment of indoor optical attocells are presented in Chapter 2 and Chapter 7 of this book. The coverage of each single attocell is very limited, and walls prevent the system from experiencing co-channel interference (CCI) between rooms. This precipitates the need to deploy multiple APs to cover a given space. However, due to the requirement for illumination indoors, the infrastructure already exists, and this type of cell deployment results in the aforementioned very high, practically interference-free bandwidth reuse. Also a byproduct of this is a reduction in bandwidth dilution over the area of each AP, which leads to an increase in the capacity available per user. The user data rate in attocell networks can be improved by up to three orders of magnitude [62].

Moreover, Li-Fi attocells can be deployed as part of a heterogeneous VLC-RF network. They do not cause any additional interference to RF macro- and picocells, and hence can be deployed within RF macro-, pico-, and even femtocell environments. This allows the system to vertically hand-off users between the RF and Li-Fi subnetworks, which enables both free user mobility and high data throughput. Such a network structure is capable of providing truly ubiquitous wireless network access.

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1.4.5 Cellular network

The deployment of multiple Li-Fi attocells provides ubiquitous data coverage in a room in addition to providing nearly uniform illumination. This means that a room contains many attocells forming a very dense cellular attocell network. A network of such density, however, requires methods for intra-room interference mitigation, while there is no inter-room interference if the rooms are separated by solid walls. Interference mitigation techniques used in RF cellular networks such as the busy burst (BB) principle [18], static resource partitioning [16, 17, 63], or fractional frequency reuse [64] have been considered. The unique properties of optical radiation, however, offer specific opportunities for enhanced interference mitigation in optical attocell networks. Particularly important is the inability of light to penetrate solid objects, which allows interference to be managed in a more effective manner than in RF communications. According to [62], for example, the VLC interference mitigation caused by solid objects in a typical indoor environment leads to a tremendous increase in the area spectral efficiency over LTE-based RF femtocell network deployment in the same indoor office environment. The presented results highlight that the improvement with respect to the area spectral efficiency can reach a factor of up to 1000 in certain scenarios.

Essential techniques for increasing wireless system capacity such as beamforming are relatively straightforward to use in VLC as the beamforming characteristic is an inherent, device-specific property related to the field of view (FOV), and no computationally complex algorithms and multiple transmitting elements are required. A simple example is provided with the technique of joint transmission in indoor VLC downlink cellular networks [65]. The application of multiple simple narrow-emission-pattern transmitters at each attocellular AP results in significant CCI reduction. The technique allows the cellular coverage area to be broken down further into areas of low interference and areas that are subject to higher interference, typically at the cell edges. Corresponding frequency allocation and constructively superimposed joint transmission can then be performed to increase the overall throughput distribution over the coverage area. A similar concept can also be realized at the receiver side, where multiple receiver elements with a narrow FOV provide a means for enhanced interference mitigation capabilities. The narrow FOV enables each photodetector to scan only a fraction of the available space. The overall combination of all photodetectors provides a wide FOV. This discretization of the receiver eyesight allows interference to be avoided by careful recombination of the output signals from each receiver element. These are only some examples of the cellular network research that is being conducted in the field of OWC.

1.5 Challenges for OWC

The following challenges are relevant for the implementation of an OWC system in practical single-link and multi-user communication scenarios. First, optical transmitter front-ends based on off-the-shelf LEDs exhibit a strong non-linear transfer of the

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information-carrying signal. Therefore, the optimum conditioning of the time-domain signal within the limited dynamic range of the transmitter front-end is essential in order to minimize the resulting non-linear signal distortion and to maximize the system throughput. In order to formulate this optimization problem, the mathematical details of the optical-to-electrical (O/E) signal conversion of the unipolar optical signals are required. Since the energy efficiency of the system is measured by the amount of electrical power required for a given quality of service (QoS), a relationship with the output optical power needs to be established. Through pre-distortion of the signal with the inverse of the non-linear transfer function, the dynamic range of the transmitter can be linearized between levels of minimum and maximum radiated optical power. While single-carrier signals can fit within the linearized dynamic range of the transmitter without distortion, in an OFDM system the non-linear distortion for a given signal biasing setup needs to be analyzed. Therefore, the achievable information rates of the OFDM system for a practical linear dynamic range of the transmitter under average electrical power and average optical power constraints are to be established.

Currently, OWC systems with IM/DD cannot fully utilize the entire available optical spectrum, because of the small electrical modulation bandwidth compared to the optical center wavelength of the optical front-ends. Therefore, system designers often resort to increasing the signal bandwidth beyond the 3-dB electrical bandwidth of the optical elements for the sake of increasing the system throughput. However, such an approach requires channel equalization techniques such as linear and non-linear equalization for single-carrier signals, and bit and power loading for multi-carrier signals. This requires channel knowledge at the receiver and the transmitter. As a result, the spectral efficiency and electrical SNR requirement of single-carrier and multi-carrier modulation schemes need to be compared in a flat fading channel and a dispersive channel under an average electrical power constraint and minimum, average, and maximum optical power constraints. Moreover, this comprehensive comparison needs to take into account the equalization penalties and the total invested electrical signal power, i.e. alternating current (AC) power and DC power.

Finally, the system model and the optimum front-end biasing setup are often tailored only to a single-link OWC scenario. Capacity enhancing techniques, where multiple LEDs are employed at the transmitter and multiple PDs are employed at the receiver, are still an open issue. The mechanisms that increase the probability of detection of the individual signals and the associated diversity techniques need to be investigated further in the context of MIMO systems. In addition, studies of the OWC systems are to be expanded with the simulation and optimization of multiple access scenarios in a network of mobile users. Because of the fact that the center wavelength is significantly larger than the modulation bandwidth of the optical front-ends, wavelength reuse in cellular OWC systems can be performed without a perceivable reduction of capacity as opposed to RF cellular systems. Therefore, a larger insight is to be gained into the maximization of the capacity of cellular OWC networks with a transition towards autonomous self-organizing interference-aware networks. This book addresses these challenges in the following chapters.

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