Introduction

Communication methods employing optical transmission means existed, albeit in a very primitive form, for millennia; well before the work of the abbot Claude Chappe. However, the amount of information thus transmitted remained low. Telecommunications, which at first were exclusively optical, really started only at the end of the 18^{th} century with the appearance of the optical telegraph. For fifty years, *wireless optics* enabled individuals to communicate over long distances. However, the quality of service (QoS) remained low due to the lack of reproducibility and reliability of both the transmitters and the receivers; of the men and the materials; and the changing nature of the air as a transmission medium.

Electricity (electric charges moving through copper) rapidly replaced optics (photons moving through the air). Information can be transferred along copper lines at relatively high flow rates. At the beginning of the third millennium, these copper-based links are still extensively exploited. Copper has served for decades as the basic material for very long distance links, and has been instrumental in establishing a network for the transmission of information across the whole globe.

The invention of the laser in 1960 paved the way to another solution, in the form of *optical telecommunication based on optical fibers*, which offers a quasi-unlimited line capacity. The almost simultaneous development in 1970−1971 of low-attenuation optical fibers, and semiconductor lasers emitting in continuous mode at room temperature, led to the explosion of wired optical telecommunications. Glass is the transmission medium for photons, and glass fibers can extend over distances of several thousand kilometers. *Wired optics* unquestionably currently dominates the fields of submarine transmissions, long-distance transmissions and interurban transmissions. It has become an integral and indispensable part of the Information Superhighway System.

For short distances, that is for the famous ‘last kilometer’ or ‘last mile’ as it is known in the telecommunication world, several different techniques, both wired and wireless, are currently competing: electricity with copper wire (xDSL, carrier current, etc.); fiber optics (glass or polymer); radio (GSM, UMTS, WiFi, WiMax, UWB, etc.); and now wireless optics. Each of these techniques presents advantages and disadvantages in terms of flows, transmission distances, costs and QoS.

Since the liberalization of the telecommunication sector, renewed interest has appeared in the digital transmission of signals in the atmosphere by laser beam. At a time when links between sites are multiplying, with an ever by increasing volume of information being transmitted, atmospheric optical links represent a wireless transmission mode with high flow rates (several Gbit/s) at short and average ranges (from a few decameters to a few kilometers). The principle of atmospheric links is the use of a wireless interconnection enabling communication between digital telephones, data-processing or video networks. This type of connection, which allows high information flow, is well-suited to short connections and, by extension, to networks with a limited dimensioning, for example wireless campus networks.

Several reasons can be offered for this revival of atmospheric optical links. Some of these reasons are of a legal nature: for instance, the exploitation of these links, in contrast to radio links, does not require any frequency authorization or any specific license. There are also economic reasons, since the deployment of a wireless link is easier, faster and less expensive for an operator than the engineering of optical cables. Finally, optics presents significant advantages compared to radio (even millimetric waves) in the race towards reaching flows of some Gbit/s. The availability of the components (receiving and modulating lasers, etc.), which are used extensively in telecommunication technologies based on optical fibers, further contributes to reducing equipment costs. Today, the world market for the wireless transmission of numerical data is primarily based on Hertzian technologies. However, these technologies present some limitations. In particular, due to their limited spectral width, it is unlikely that they alone will be capable of meeting the ever-increasing requirements in flows.

Throughout this book, the focus will be on the 1.5 µm wave. While the demonstrations and the reasoning can be applied to other photon wavelengths, our focus on the 1.5 µm wavelength is a deliberate choice, due to our belief that this wavelength will become the basic wavelength for wireless optical telecommunication systems with high flows. The advantages offered by this wavelength include a better ocular safety; greater availability of industrial components; the emission of photons at 1.5 µm using semiconductors or rare earth erbium; the possibility of communication systems operating in the continuation of other communication systems based on fibers (and therefore operating at 1.5 µm);

and less sensitivity to disturbances induced by the ambient light (sun, different illumination conditions, remote controls, etc.).

The objective of this book is to show how free-space optics, which is already commonly used for information transfer, is also taking off as a telecommunication technique, and is becoming an integral and essential part of data-processing architecture and telecommunications due its numerous advantages (flow, low cost, mobility of materials, safety, etc). First, a history of wireless optical telecommunications is presented, including the application of the principles of electromagnetism to free-space optics. Second, we describe transmitters and receivers of optical beams, which are the basis of any optical communication system: these devices were responsible for the first truly significant advances in the performances of these systems. Third, we devote special attention to the problems associated with the propagation of photons, both in the absence and in the presence of obstacles, since these are key issues for gaining an understanding of future telecommunication systems based on wireless optics. Finally, we consider standards as well as safety and confidentiality issues.