Chapter 1

Introductory Chapter: The Path to the Future

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1. Introduction

The idea to use light for communication purposes was envisioned many years ago. However, the origins of optical communications trace back to 1966 when Charles Kao suggested the possibility that low-loss optical fibers could be competitive with coaxial cable and metal waveguides for telecommunication applications. However, it was not until 1970 when Corning Glass Works announced an optical fiber loss less than the benchmark level of 10 dB/km that commercial applications began to be realized. Quickly, the purifying process was refined, and in the late 1980s, optical fibers with an attenuation of 0.2 dB/km were manufactured and commercialized. Surely, our society was shaped by the concepts developed by Charles Kao in the 1960s. In recognition of his pioneering work, in 2009, Charles Kao was awarded the Nobel Prize in Physics along with Willard S. Boyle and George E. Smith.

What followed from 1970 to the first decade of twenty-first century was an extraordinary race that has led to an enormous increase in both the maximum transmission capacities and the transmission distances, and, therefore, to the contents delivered. Nowadays, in addition to the voice, data, and video, it is common talk references to global internet video, virtual reality, augmented reality, and gaming highlights. All of these applications will be a reality in the next years and will be supported by an optimized optical network. However, this race for ever better performance does not stop here. In the upcoming years, developments in several areas of optical communication from hardware, software (algorithms), signal processing to networks and emerging technologies [2] will be the target of much attention from academia and industry.

2. Challenges and Opportunities for the next years

The optical hardware is related to the need for low losses, low dispersion, high speed, and high capacity. So, in this topic, it is possible to cover the following areas:

- New optical fibers for next generation optical networks;
- Optical amplification and regeneration;
- Spatial multiplexing;
- Coherent transceivers.

In relation to the software and signal processing, the main objective is to improve encoding of digital data onto lightwaves and to recover the information reliably at the receiver with the maximum efficiency. Examples of some topics related to this thematic are as follows:

- New modulation formats;
- Digital signal processing;
- Optical signal processing;
- Nonlinear channel modeling and mitigation and forward error correction (FEC).

Then follows the block of networks, where the main objective is to improve the number of point-to-point links between two extremes in different types of networks: core, metropolitan, access, and data center networks. Topics under development in this area are as follows:

- Long-haul networks;
- Access networks;
- Optical communications for data centers.

Finally, the last block is related to some emerging technologies, which are in intense research and possibly will be certain in the next future. Here, the features are as follows:

- Optical integration and silicon photonics;
- Optical wireless communication;
- Quantum communication.

3. The Zettabyte Era

In conclusion, from the first generation of optical systems to the most current, communication based on optical fibers has revolutionized the way people and the world are related. This evolution is constant and will continue to respond to people's increasing demand for data rates. The great development of the Internet era is also due to the evolution of the optical networks. The annual IP traffic is now measured in Exabyte. In order to understand this

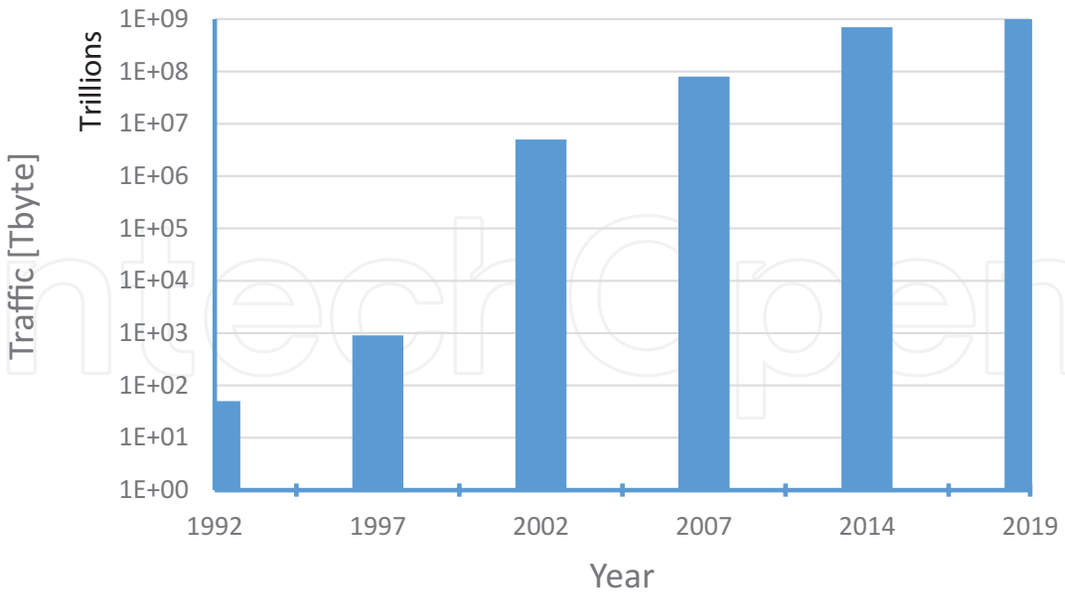

Figure 1. IP traffic: past, present, and future [2].

growth, **Figure 1** shows the past, present, and the predicted global Internet traffic according to Cisco's statistics [1, 2].

The bandwidth requirements are the cause for the rapid growth of Internet traffic over the past decade, and that growth has been exponential. We can expect that the bandwidth requirements in the second decade of this century will be ranging from 100 Mbps to 1 Gbps for residential access users, 10–40 Gbps for the majority of business users, and 100 Gbps to 1 Tbps for some institutions, such as government agencies or major research labs.

4. Conclusion

This book aims to introduce and treat one of the emerging technologies in the field of optical communications: optical wireless communication. This technology is a dynamic area of research and development because a growing demand by the end users for bandwidth in mobile communications to support broadband wireless services such as high definition TV mobile video, video conference high speed Internet access, and so on. As the global demand for bandwidth continues to increase, and the conventional radio frequency (RF) cellular microwave technologies have limitations in terms of bandwidth and spectrum, this solution based on optical wireless communication is one of the most promising alternative technologies for indoor and outdoor scenarios.

Another subject of interest in this book is related to optical hardware (lasers, modulators, optical amplifiers, and optical receivers), in order to improve the performance of microwave photonic links.

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