Abstract

This thesis explores the topic of optical transmission and networks, addressing the challenges and trends in future optical communication systems. The development of solutions that can support the continuous growth demanded from optical networks are an extremely important issue, due to the increasing of digital services and applications, 5G deployment and many other factors, which are contributing to stress the actual infrastructure to its limit. The first chapter provides an overview of the advancements in optical transmission technology during the past 50 years, from the first systems providing capacity of dozens of Mbps to the most recent ones, with provide transmission capacity of several signals of hundreds Gbps each. Moreover, we identify the key challenges faced by optical networks and discusses the emerging trends that shape the future of optical transmission.

The second chapter focuses on the modeling of the physical layer in optical line systems (OLSs), which compose the optical networks. This chapter delves into the detailed information about the components that constitute the OLS, e.g. fibers, transceivers, and amplifiers. The optical network architecture is also explored, encompassing topics such as geographic optical network structure, software-defined networking (SDN), disaggregated networks, and finally the optical network transport model. This chapter also discusses the concept of multi-band transmission (MBT) systems, technology which focus on increase the fiber spectral bandwidth used for transmission, elucidating their benefits and challenges.

In the third chapter, we investigate the launch power in MBT systems topic. Firstly, we analyze the impact of launch power on the quality of transmission (QoT) for this scenario. Then, we explore the strategy of tilt/offset with a brute-force approach to optimize the launch power. Additionally, we propose the application of a genetic algorithm (GA) to refine this strategy, aiming to reduce the computational effort while improving the performance of the system. We shown that, besides the

fact that increasing the fiber spectral usage for increase the number of transmitted channels, the launch power optimization can mitigate the impairments raised by this scenario.

Moving forward, the fourth chapter focuses on the upgrade and design of multi-band optical networks. We start by evaluating the impact of incorporating different spectral bands, considering their effects on existent systems performance, as well as the capacity increasing provided by this upgrade. Furthermore, we propose a network design specifically for the C+L+S band system, with the objective of achieving comparable performance to the C-band system while minimizing the incremental costs.

Finally, in the fifth chapter, we present the conclusions drawn from our research. We summarize the findings from each chapter, highlighting the advancements made in MBT systems and their implications for future network design and optimization. We think that this thesis provides valuable insights into the evolution of optical transmission, modeling techniques, and optimization strategies, offering guidance for the development of efficient and cost-effective multi-band optical communication networks in the future.