Optical Communication Theory and Techniques

<table>
<tr><th>Communication Theory and Digital Transmission</th><th>Fundamentals of Optical Communications</th></tr>
<tr><td>Teacher: Enrico Forestieri
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First semester
Written exam</td><td>Teacher: Marco Secondini
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Second semester
Oral exam</td></tr>
<tr><td>• Data transmission over Gaussian channels
• System design for bandlimited channels
• Channel and line coding
• Adaptive equalization</td><td>• Optical transmitters and modulation formats
• Impact of fiber linear and nonlinear transmission impairments
• Optical receivers and noise</td></tr>
<tr><td colspan="2">• Co-requisites: Fundamentals of Signals, Systems and Networks
• Final exams are organized in two parts and are typically scheduled on the same day. The first part is a written test on digital transmission theory, while the second part is an oral examination on the fundamentals of optical communications. It is possible to take one exam part only. Each exam part is valid for one solar year. The final mark is computed as a weighted average of the two exams.</td></tr>
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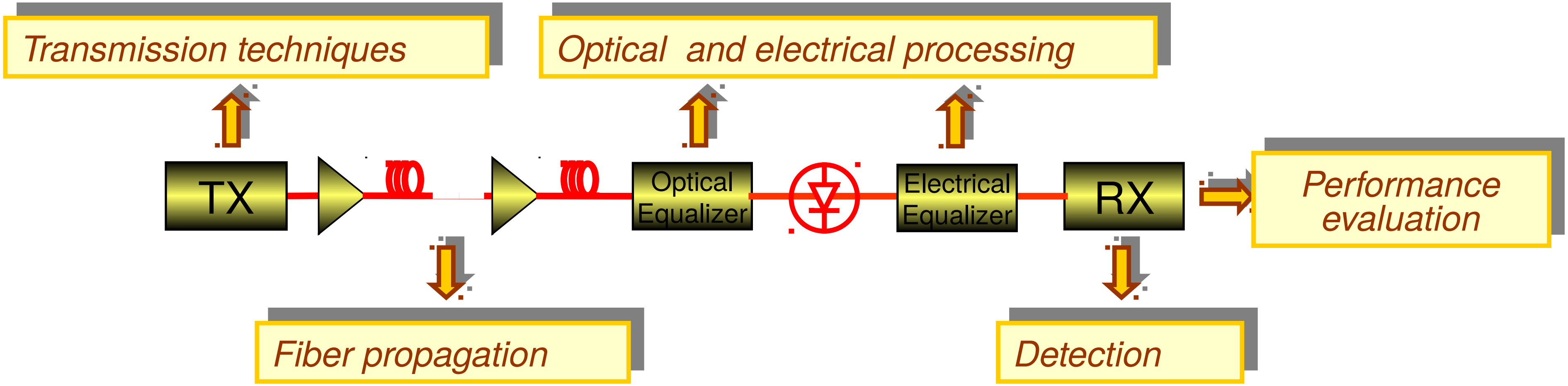
Learning Objectives

The course will introduce the students to the fundamental principles of communication theory and data transmission with reference to the design criteria of modern high-capacity optical systems



- Introduction to the concepts of digital transmission and detection theory.
- Understanding of the basic concepts for the analysis and design of digital communication systems, with particular attention to optical systems.
- Ability to select a suitable communication system, given the constraints imposed by the transmission channel, in relation to the desired performance.
- Ability to account for transmission impairments in the design of optical networks.

Available Theses

- **Modulation formats/coding techniques for optical short-reach interconnects**
  Data centers are experiencing an exponential increase in the amount of network traffic that they have to sustain. As a consequence, optical interconnects have gained much attention as a promising solution for inter- and intra-data-center communications, offering high information rates, low latency, and reduced energy consumption. The aim of this thesis is the investigation of efficient optical modulation formats for reliable communication over short distances (up to some tens of kilometers), where the main constraints are given in terms of complexity and energy efficiency.
- **Spectral broadening in nonlinear optical fibers**
  Signal propagation in optical fibers is governed by the nonlinear Schrödinger equation. As a result, signals in fiber-optic communication systems are affected by several detrimental nonlinear effects, whose relevance increases with power. One important effect is the evolution of the signal power spectral density during propagation, with the rise of new spectral components and a consequent spectral broadening. Such a spectral broadening may be responsible for inter-channel interference in WDM systems and have a negative impact on spectral efficiency. The aim of this thesis is studying and modeling the effect of spectral broadening in nonlinear optical fibers and investigate its impact on spectral efficiency.
- **Impairment analysis in filterless optical networks**
  The use of coherent detection and digital signal processing in optical communications has paved the way for the design of filterless optical networks. In such networks, demultiplexing of optical signals at different wavelength is performed in the electrical domain. This brings an advantage in terms of cost and complexity, at the expense of a loss in terms of performance. The aim of this thesis is that of studying and modeling the most relevant impairments that affect system performance in such a scenario.