Seminário em Engenharia Matemática

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Nonlinear Effects in Digital Communications: Analytical Evaluation of Their Effects and How to Use Them to Improve the Performance

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Abstract:
It is widely accepted that nonlinear effects is something that should be avoided in digital communications. There are two main reasons for this. The first one is that the theoretical analysis of the impact of a given nonlinear device is not simple. The second, and more important, is the nonlinear devices can lead to significant spectral widening effects and/or performance degradation. Since the signals associated to widely employed techniques like OFDM (Orthogonal Frequency Division Multiplexing) and/or MIMO (Multi-Input, Multi-Output) schemes can have very large envelope fluctuations and PAPR (Peak-to-Average Power Rate), they are prone to nonlinear distortion effects like the ones associated to quantizers and power amplifiers. For these reasons, there has been a huge effort in the design of quasi-linear amplifiers, as well as techniques to reduce the PAPR of digital signals.
It was recently shown that strong nonlinear distortion effects do not necessarily mean performance degradation. This is due to the fact that the nonlinear distortion component has some information on the transmitted signals, which can be employed to improve the performance. In fact, the optimum maximum likelihood (ML) performance of nonlinear OFDM schemes can even be better than the performance of the corresponding linear. However, the complexity of optimum ML receivers is prohibitively high, even for a moderate number of subcarriers, which lead to the development of practical, sub-optimum receivers able to achieve the optimum performance of nonlinear OFDM.
In this talk we start by making an overview on the common nonlinear characteristics that arise in digital communications, as well as techniques for studying analytically the impact of nonlinear effects on given signals, with emphasis on the signals associated OFDM techniques and MIMO schemes. Then we present some key results on the impact of nonlinear operations in the spectral occupation and performance. Next, we study the optimum performance of nonlinear OFDM and MIMO schemes, showing the remarkable result that nonlinear techniques can have much better performance than the corresponding linear ones. In fact, a nonlinear device at the transmitter

can be regarded as a kind of channel coding scheme if it is properly designed. Finally, we present some practical receivers able to harvest these potential nonlinear performance gains.

Apoio: IEEE Vehicular Technology Society, Portugal

Nota biográfica:

Rui Dinis received the Ph.D. degree from IST, Technical University of Lisbon, Portugal, in 2001 and the Habilitation in Telecommunications from FCT, Nova University of Lisbon (UNL), in 2010, where he is an associated professor. During 2003 he was an invited professor at Carleton University, Ottawa, Canada. He was a researcher at CAPS-IST, from 1992 to 2005 and a researcher at ISR (Institute for Systems and Robotics) from 2005 to 2008. Since 2009 he is a researcher at IT (Instituto de Telecomunicações).

Rui Dinis is an IEEE Distinguished Lecturer and is or was editor of several IEEE journals (Transactions on Communications, Transactions on Wireless Communications, Transactions on Vehicular Technology, Open Journal on Communications), as well as Elsevier Physical Communication. He was also a guest editor for several special numbers.

He was part of the organizing committee of several major IEEE conferences (ICT (2014), VTC (2017 (Fall), 2018 (Spring), 2019 (Spring), 2020 (Spring), 2021 (Spring and Fall), 2022 (Spring)), GLOBECOM (2020 and 2021) and ISWCS (2018)). He is also a member of several technical committees of IEEE Communications Society (SPCC, RCC, WC and CT).

Rui Dinis has been actively involved in several national and international research projects in the broadband wireless communications area. He has 20 PhD students (current and past), published 5 books, over 150 journal papers and book chapters and over 400 conference papers, and has 15 patents (attributed or pending).

He was involved in pioneer projects on the use of mm-waves for broadband wireless communications and his main research activities are on modulation and transmitter design, nonlinear effects on digital communications and receiver design (detection, equalization, channel estimation and carrier synchronization), with emphasis on frequency-domain implementations, namely for MIMO systems and/or OFDM and SC-FDE modulations. He is also working on cross-layer design and optimization involving PHY, MAC and LLC issues, as well as indoor positioning techniques.