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INFORMATION OF THE DISSERTATION

PhD candidate: **PHAM VAN QUYET**

Title: **PERFORMANCE OPTIMIZATION FOR SIMULTANEOUS WIRELESS INFORMATION AND POWER TRANSFER SYSTEMS WITH THE AID OF INTELLIGENT REFLECTING SURFACES**

Major: **Telecommunications Engineering**

Major code: **95.20.208**

Scientific advisor:

Assoc. Prof. Ha Hoang Kha

Institution: **Ho Chi Minh City University of Technology – Vietnam National University Ho Chi Minh City.**

Dissertation's objectives

The explosive development of high-quality wireless information services has created an urgent demand for further enhancement of spectral efficiency (SE) and energy efficiency (EE) in telecommunications networks. Moreover, the rapid increase in the numbers of mobile devices and dense network connections has posed significant challenges in terms of energy consumption and interference management. Therefore, the next-generation communication systems not only need to be optimally designed but also prioritize the use of energy-efficient devices such as intelligent reflecting surfaces (IRS) to enhance system performance while saving energy. Hence, this thesis focuses on the study of multi-user multi-input multi-output (MU-MIMO) simultaneous wireless information and power transfer (SWIPT) systems supported by an IRS. The primary objective of the thesis is to propose algorithms to optimize the performance of IRS-aided MU-MIMO SWIPT systems under various constraints.

Contributions of the dissertation

The thesis has the following main contributions:

- Proposing an algorithm to maximize the sum harvested energy (SHE) of users in the MU-MIMO SWIPT systems supported by an IRS. In this system, users utilize power-splitting (PS) technique to perform energy harvesting (EH) and information decoding (ID) concurrently. With a non-linear energy harvesting (NLEH) model, the design problem is non-convex. To address this challenge, the thesis proposes an alternating optimization (AO) algorithm to iteratively optimize the transmit precoding matrices

(TPCs) at the base station (BS), PS factors at the users, and phase shift matrix at the IRS. Simulation results demonstrate that the convergence of the proposed algorithm is guaranteed and the SHE of the IRS-aided MU-MIMO SWIPT is superior compared to a system without IRS.

- Proposing algorithms to maximize SE and EE in the IRS-aided MU-MIMO SWIPT underlay cognitive radio (CR) system with imperfect channel state information (CSI) of primary users (PUs). The optimization problems are non-convex due to coupled design variables, the non-linearity of the energy harvesting model, and imperfect CSI. To address these challenges, firstly, appropriate surrogate functions are identified, and linear matrix inequality (LMI) constraints are utilized to transform the non-convex optimization problems into convex ones. Then, an AO algorithm is proposed to iteratively find optimal solutions for design variables including TPC at the secondary base station (SBS), PS factors at the secondary users (SUs), and phase shift matrix at the IRS. Simulation results demonstrate the convergence of the proposed algorithm is guaranteed, and the robustness of the design algorithm shows effectiveness across various channel error levels. Furthermore, the results also indicate that the SE and EE of the IRS-aided system outperform those without IRS support.
- Proposing an algorithm to maximize SE of the secondary network in the active IRS-aided MU-MIMO SWIPT underlay CR system subject to constraints on the minimum harvested energy at the secondary users, the interference power (IP) at PUs being below the allowable threshold, and constraints on the reflection amplitude and amplification power at the IRS. The design problem is non-convex, hence cannot be solved directly. To address these challenges, the thesis exploits the relationship between the minimum mean squared error (MMSE) and the data rate function to handle the non-convex objective function. Additionally, LMIs are utilized to handle non-convex IP constraints due to imperfect CSI of PUs. Then, an AO algorithm is proposed to iteratively optimize TPC matrices at the SBS, PS factors at SUs, and reflection coefficient matrix at the IRS. Finally, simulations are conducted to evaluate the effectiveness of the proposed algorithm and the system performance. Simulation results show that the SE of the active IRS-aided system is significantly improved as compared to the passive IRS-aided system.
- Proposing a multi-objective optimization algorithm in an IRS-aided MU-MIMO SWIPT. The objective of the thesis is to simultaneously maximize SR and SHE of

users. To achieve this objective, firstly, the thesis formulates two single-objective optimization problems (SOOPs): one for maximizing SR and the other for maximizing SHE. Next, the thesis constructs a multi-objective optimization problem (MOOP) to maximize SR and SHE, simultaneously. Subsequently, the thesis applies a modified weighted Tchebycheff method to transform the MOOP into an SOOP. Both SOOPs and MOOP are non-convex optimization problems. To solve these problems, the thesis identifies appropriate surrogate functions and proposes an AO algorithm to iteratively optimize design variables including TPC matrices at the BS, PS factors at users, and phase shifts at IRS. Simulation results show that the convergences of both SOOP and MOOP algorithms are guaranteed. Additionally, the trade-offs between SR and SHE are comprehensively evaluated.

The thesis has proposed optimization algorithms to comprehensively evaluate various aspects of IRS-aided MU-MIMO SWIPT systems. Simulation results demonstrate that the performance of the IRS-aided systems in terms of harvested energy, SE, and EE is significantly improved compared to those of systems without IRS and IRS-aided systems with fixed-phases. Additionally, the results also indicate that the performance of systems using an active IRS is superior to those using a passive IRS.

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