THE ABSTRACT OF DOCTORAL THESIS

a) Abstract:

- Author: Pham Thi Quynh Trang
- Dissertation Title: Research on Solutions to Enhance Wireless Communication Performance of UAV-Integrated Systems
- Thesis field: Telecommunications Engineering Code: 9520208

b) Training Institution: University of Engineering and Technology, Vietnam National University, Hanoi

c) Content of the abstract:

1- Research objectives of the thesis

The overall objective of this thesis is to propose several technical solutions to improve resource utilization efficiency and service quality for UAV-supported information systems. Specifically, the thesis focuses on achieving the following objectives:

- Improving the accuracy of UAV channel attenuation prediction: Research and develop machine learning and deep learning models to predict attenuation for A2A and A2G links. This includes proposing the use of the Gravitational Search Algorithm (GSA) to automate hyperparameter setting, thereby optimizing the performance of the prediction models.

- Evaluating the communication efficiency of UAVs acting as base stations and relay nodes: Establishing analytical expressions to determine the optimal altitude and elevation angle, and analyzing their impact on coverage radius and power gain. Simultaneously, the study investigates the impact of velocity on the stability of transmission speed when UAVs act as mobile relay nodes, thereby proposing a closed-form expression to determine the appropriate operating velocity to maintain link stability.

- Develop spectrum access and sharing solutions based on RSMA: Building an uplink transmission model combining cognitive radio and rate-separated multiple access. The thesis identifies the conditions for pairing priority users (PU) with secondary users (SU) and the signal separation process at the base station. Simultaneously, it proposes a PU-SU pairing algorithm to increase the number of users served, contributing to improved spectrum utilization efficiency of the system.

2- Research scope

The research scope of this thesis focuses on key technical aspects of UAV-assisted wireless communication systems, including:

- Physical and geometric characteristics of UAV links: UAV channel models, particularly path loss models for air-to-air (A2A) and air-to-ground (A2G) links under different propagation environments.

- UAV communication systems: System models in which UAVs operate as aerial base stations to extend coverage or as relay nodes for long-range communications.

- Multiple access and resource management techniques: Transmission models combining cognitive radio and rate-splitting multiple access (RSMA), along with user pairing strategies and signal separation techniques at the base station.

3- Research Methods.

This thesis employs a comprehensive research methodology that combines theoretical analysis, data-driven modeling, and numerical simulation. The main approaches are summarized as follows:

- Theoretical analysis and system modeling: Information theory and wireless communication theory are utilized to develop system models for UAV-assisted scenarios. This approach provides a foundation for deriving mathematical relationships between key system parameters (e.g., position, velocity, and transmit power) and performance metrics such as data rate and outage probability.

- Optimization and approximation techniques: Closed-form expressions are derived to address the optimization of spatial parameters (e.g., altitude and elevation angle) and spectrum resource allocation. These analytical results offer insights into optimal system design and practical deployment guidelines.

- Data-driven and deep learning approaches: Deep learning models are employed to predict channel characteristics in complex propagation environments. The predicted results are further used as inputs for optimization and resource allocation processes.

- Numerical simulation and performance evaluation: MATLAB and Python are used to conduct Monte Carlo simulations. This step aims to (i) validate the accuracy of the proposed models and algorithms, and (ii) evaluate the performance of the proposed methods in comparison with conventional approaches under identical conditions.

4 – ***Main results.***

- This thesis develops a hyperparameter optimization framework for machine learning and deep learning models applied to path loss prediction in both air-to-air (A2A) and air-to-ground (A2G) links. By integrating the Gravitational Search Algorithm (GSA) with models such as KNN, decision tree (DT), random forest (RF), and LSTM networks, the proposed approach significantly improves prediction accuracy compared to conventional statistical models. This contribution provides a data-driven channel prediction tool that supports the

design and optimization of UAV-assisted communication systems in realistic environments.

- The thesis derives analytical approximation models to obtain closed-form expressions for determining the optimal altitude, elevation angle, and operating velocity of UAVs when acting as aerial base stations or relay nodes. The impact of these parameters on communication performance is analyzed in terms of coverage radius, power gain, and data rate. Unlike purely simulation-based studies, this contribution explicitly reveals the relationships among spatial configuration, coverage region, and received signal power, thereby providing practical guidelines for UAV deployment.

- The thesis proposes an uplink transmission framework based on rate-splitting multiple access (RSMA) in cognitive radio networks to enhance spectrum utilization efficiency. The main contributions include establishing analytical conditions for primary user–secondary user (PU–SU) pairing and developing a low-complexity access control algorithm. The proposed method increases the number of served users and improves the overall system data rate compared to conventional non-orthogonal multiple access (NOMA) schemes.

4- Conclusion.

This thesis proposes several solutions to improve resource utilization efficiency and quality of service (QoS) in UAV-assisted communication systems for next-generation wireless networks. The research addresses the problem of transmission performance optimization under constraints related to UAV mobility, spectrum scarcity, and QoS requirements. The results provide useful insights for the analysis and design of UAV-assisted communication systems in next-generation wireless networks.

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CONFIRMATION FROM THE TRAINING UNIVERSITY