

Fiche d'informations sur la thèse



 **Nom du doctorant : Ibtissam LARHLIMI**

✓ Master en Systèmes de Télécommunications et Réseaux Informatiques Faculté Polydisciplinaire, Université Sultan Moulay Slimane.

✓ Licence Sciences et Techniques (LST) en Systèmes d'Informations Répartis (SIR),
Faculté des Sciences et Techniques de Marrakech, Université Cadi Ayyad.

 **Sujet de Thèse :** Optimiser les performances des réseaux de capteurs sans fil à l'aide d'algorithmes métaheuristiques et de méthodes d'apprentissage automatique

👉 **Directeur de Thèse** : Pr. Hicham MOUNCIF, PES Faculté des Sciences Appliquées de Béni-Mellal, Université Sultan Moulay Slimane, Béni Mellal.

 **Co-Directeur de Thèse :** Mr. OUCHITACHEN Hicham, MCH Faculté des Sciences Appliquées de Béni-Mellal, Université Sultan Moulay Slimane, Béni Mellal.

 **Discipline : Informatique**

 **Laboratoire :** Laboratoire d'Innovation en Mathématiques, Applications & Technologies de l'Information-LIMATI, Faculté des Sciences Appliquées de Béni-Mellal, Université Sultan Moulay Slimane, Béni Mellal, Maroc



1. **I. Larhlimi**, M. Lmkaiti, M. Lachgar, H. Ouchitachen, H. Mouncif, “Optimizing Energy in Wireless Sensor Networks with Machine Learning,” 2nd Mediterranean Smart Cities Conference (MSCC 2025), Martil–Tetouan, Morocco, 2025.
 2. **I. Larhlimi**, M. Lachgar, H. Ouchitachen, A. Darif, H. Mouncif, “Contribution to Solving the Cover Set Scheduling Problem and Maximizing Wireless Sensor Networks Lifetime Using an Adapted Genetic Algorithm,” International Conference on Artificial Intelligence & Industrial Applications (A2IA 2023), Meknes, Morocco, 2023.
 3. **I. Larhlimi**, M. Lachgar, H. Ouchitachen, A. Darif, H. Mouncif, “A Genetic Algorithm Approach to the Cover Set Scheduling Problem for Maximizing the Lifetime of Wireless Sensor Networks,” 3rd International Conference on Artificial Intelligence and Computer Vision (AICV 2023), Marrakesh, Morocco, 2023.
 4. **I. Larhlimi**, M. Lachgar, H. Ouchitachen, A. Darif, H. Mouncif, “Maximization of Lifetime in Wireless Sensor Networks Using Pattern Search Algorithm,” International Conference on Artificial Intelligence and Green Computing (ICAIGC 2023), FST-USMS, Beni Mellal, Morocco, 2023.
 5. M. Lachgar, **I. Larhlimi**, A. Darif, H. Ouchitachen, H. Mouncif, “Low Overhead Routing in a Lightweight Routing Protocol,” in The 3rd International Conference on Artificial Intelligence and Computer Vision (AICV 2023), Lecture Notes on Data Engineering and Communications Technologies, vol. 164, Springer, Cham, pp. 242–250, 2023. DOI: 10.1007/978-3-031-27762-7_23.
 6. M. Lachgar, **I. Larhlimi**, A. Darif, H. Ouchitachen, H. Mouncif, “Performances Evaluation of LRP Protocol in Wireless Sensor Network,” in Artificial Intelligence and Green Computing, Lecture Notes in Networks and Systems, vol. 806, Springer, Cham, pp. 123–137, 2023. DOI: 10.1007/978-3-031-46584-0_10.
1. **I. Larhlimi**, M. Lachgar, H. Ouchitachen, A. Darif, H. Mouncif, “Evaluation of the Performance of Pattern Search and Genetic Algorithms for Enhancing the Lifetime of WSNs,” in Artificial Intelligence and Smart Environment, CRC Press, 2025. DOI: 10.1201/9788770047746-15.



Abstract

Wireless Sensor Networks (WSNs) have become a vital component of modern intelligent systems, enabling real-time monitoring in fields such as environmental surveillance, agriculture, healthcare, and smart infrastructure. However, due to the limited energy resources of sensor nodes, maximizing the operational lifetime of such networks remains a critical and challenging task. Effective energy management is crucial for prolonging the operational lifespan of wireless sensor networks (WSNs) that include a substantial number of sensors. Simultaneously activating all sensors results in a fast depletion of energy, thus diminishing the overall lifespan of the network. This thesis addresses the Maximum Coverage Set Scheduling Problem (MCSSP), a combinatorial optimization problem that involves selecting and scheduling subsets of sensors to ensure continuous coverage of a target area while minimizing energy consumption.

The research begins by formally modeling the MCSSP, incorporating realistic constraints such as sensing range, battery capacity, and activation time. Several optimization approaches are explored to solve this NP-hard problem. First, a Pattern Search Algorithm (PSA) is proposed to locally optimize sensor schedules based on neighborhood exploration. Next, a Genetic Algorithm (GA) is developed to evolve efficient activation strategies using bioinspired mechanisms. This is followed by a Particle Swarm Optimization (PSO) method, which explicitly models active and standby energy usage to provide a more balanced energy consumption profile. Following this, the thesis introduces a supervised machine learning framework, leveraging models such as XGBoost to predict sensor lifetime and inform adaptive scheduling decisions in dynamic environments. This work offers a comparison of the performance of the proposed approaches by looking at how well they operate in extending the lifetime of the network. The performance of the suggested approaches is assessed through simulations, and comparisons to the other algorithms exist in the literature. The results indicate that our approaches not only maximize network lifetime, but also enhance the efficiency and efficacy of solving the MCSS problem. These methods represent a significant improvement in the management of energy consumption in WSNs

Keywords: Optimization; Maximum Network Lifetime; Wireless Sensor Network; Coverage; Sets Scheduling; Genetic Algorithm; Pattern Search Algorithm; Particle Swarm Optimization; Machine Learning; supervised; XGBoost.