PhD Thesis proposal

General Information	
PhD Thesis Title	*Nano modular robots: New optimization algorithms for leader election and shape formatting phases*
School	*Faculty of sciences*
Research Unit	NA
Laboratory	NA
Axis	NA
PhD Supervisor	Name & Title : Dr. Charbel Fares Dr. Bachir Habib Email : charbelfares@usek.edu.lb bachirhabib@usek.edu.lb	University Address : Holy Spirit University of Kaslik- USEK
Co-supervisor (if applicable)	Name & Title : Dr. HDR. Abdallah Makhoul Email : abdallah.makhoul@univ-fcomte.fr	University Address : Femto-ST Institute, Computer science department (DISC) Université Bourgogne Franche-Comté Belfort, France
Location (s)	Location 1: USEK	Work shift calendar /per year (%): 50%
	Location 2: Université Bourgogne Franche-Comté	Work shift calendar /per year (%): 50%
Funding and scholarship	NA, a CNRS application will be submitted	

Applicant Profile and/or Special Requirements	Master M2 (or equivalent) in CS

Subject's national or worldwide Context, Objectives & Research lines (limit : 300 words)

Context:

Nano modular robots is a term used to define the ability of a system to change its physical properties in a programmable way based on multiple inputs gathered from its environment.

The system consists of simple computational particles that can establish and release bonds, can compute, and can actively move in a self-organized manner.

The particles have modest computational power and can only process local information. Moreover, they have the following properties: each particle is anonymous, in other words, the particles do not have a unique identifier or any identifier of any kind. Each particle knows the labels of the ports that can communicate with the particle from the neighborhood. Finally, each particle knows the state of its neighbors.

Problematic:

One of the main problems in distributed systems is to elect a leader. In some scenarios, the leader election is done to facilitate shape formation. Particles will be moving based on the conditions and the status of the leader. Multiple challenges occurred when running the leader election algorithm. Since the algorithm in some articles is based on the probability of a coin flip is some steps, we may end up with no leader. In other papers, the author used an arbitrary identification for the particles. Then run a comparison phase among the particles based on their previously defined identification. In this case, we might end up with the same identification for different particles that might lead to fail in the leader election.

In other hand, the design of new optimized algorithm for leader election and shape formatting must be considered to improve the complexity in time and space.

Research lines:
- State of art on Nano modular robots, leader election and shape formatting.
- Simulation of existing algorithms.
- Proposition of new optimized algorithms.
- Implementation and results.

Outcomes (OCs): What do we wish to achieve?	
OC1:	New optimized algorithms for leader election
OC2:	Shape formatting algorithms for new 2D and 3D scenarios
OC3 :	Design of Decision making layers for Nano modular robots

References (R) (5 most recent peer-reviewed publications)	
R1:	"Robot Co-design: Beyond the Monotone Case", L. Carlone, C. Pinciroli, ICRA 2019.
R2:	"usBot: A Modular Robotic Testbed for Programmable Self-Assembly", U. A. Fiaz, J. S. Shamma, 2019.
R3 :	"Optimal Distribution of Active Modules in Reconfiguration Planning of Modular Robots", M. Yao, X. Xiao, C. H. Belke, H. and J. Paik, Journal of Mechanisms and Robotics, 2018.
R4 :	"Algorithmic Foundations of Programmable Matter", B. Spring, F. Sándor, P. Matthew, C. Scheideler, Dagstuhl Reports 2019.
R5 :	"A modular bilateral haptic control framework for teleoperation of robots", Z. Y. Bayraktaroglu, O. F. Argin and S. Haliyo, Robotica journal 2019.