جامعة عبد المالك السعدي
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Pole for Doctoral Studies
Center for Doctoral Studies
Sciences, Technologies, and Medical Sciences

ANNOUNCEMENT OF DOCTORAL THESIS DEFENSE

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Will present here research work with the aim of earning a Doctorate

Doctoral program: Sciences and Technique Engineering
Discipline: Computer Sciences
Specialty: Computer Sciences

On 27/09/2025 at 10H00 at the Conference Hall of the National School of Commerce and Management of Tangier, UAE
Under the Theme

Modeling and Implementation of Data for IoT Agroecology Applications by means of a UML Profile and Model Driven Architecture

Front of the jury composed of :

First Name & Last Name	Establishment	Designation
Pr. MABROUK Aziz	FS of Tetouan, UAE	President
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Pr. BIMONTE Sandro	INRAE of France	Guest
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Abstract

The Internet of Things (IoT) is a collection of devices connected via the Internet or other communication technologies. These devices can sense environmental information such as temperature, humidity, wind, etc, and send the measured data. In addition, there is a smarter version of sensors that can change their sending/sensing policies based on internal information. In the agricultural context, IoT is very useful since the information gathered is very important to understanding the ideal conditions for each plant's growth.

In agriculture, robots are also present to minimize human presence and perform labor-intensive tasks, especially with the appearance of "Autonomous Robots" which can function with little to no human intervention. Thanks to these robots, tasks like spraying, harvesting, and weeding are performed automatically. The integration of robots with IoT has given birth to the Internet of Robotic Things (IoRT). IoRT has elevated IoT applications thanks to the computational power of autonomous robots.

Data generated from IoRT systems is complex, especially in smart farming contexts, where data can be received from multiple devices, each with its own data sending frequency. For instance, sensors send data periodically, however, robots send real-time data. In addition to the difference in the temporal aspect, the types of data are also different. Data can be spatial, spatio-temporal, time-series, odometry, etc. Additionally, data is susceptible to variety, which indicates non-relational data (semi-structured and unstructured data), and variability, which indicates the coexistence of different representations of the same data within the same dataset. In this context, Business Intelligence is crucial to analyze IoRT data and provide users with accurate insight, leading to an increase in crop production. In addition to data complexity, IoRT systems in smart farming contain multiple users, namely robot experts, sensor experts, farmers, stakeholders, etc.

In this context, conceptual modeling is essential for designing users' needs. Additionally, model-driven frameworks help in the implementation process and even generate code automatically.

The aim of this thesis is to provide end-users with understandable means to analyze IoRT data, respecting data variety and variability constraints, and IT-users with tools and techniques to automatically implement end-users' needs while reducing coding time and errors. In other words, the goal is the design and implementation of IoRT-based applications in smart farming.

To achieve these goals, the main problems encountered within this thesis are:

1. Designing smart sensors: In order to benefits from smart sensors functionalities, the inner logic adopted to change its behaviors must be represented. To solve this issue, a UML profile that models different representations of internal/external data expressed from the same sensor and the logic used to adapt the sending/sensing policies to sudden environmental changes is proposed.

2. Handling data variety and variability: IoRT data is subject to variety, variability, and complex data types. These formats of data must be handled in order to provide good data analysis to ensure accurate decision-making. To solve this problem, a conceptual model is proposed that handles name/type variability, extendability, and complex data types in multidimensional design.

3. Requirement definition: IoRT systems in smart farming are dedicated to farmers who don't acquire any IT skills, making it a complex task for them to define their needs from the system, especially when requiring continuous queries. To solve this, the proposed approach introduces (i) stream tables as a way to let non-IT end-users communicate their requirements about continuous queries, (ii) UML stereotypes to precisely model these requirements, and (iii) a prototyping tool to let users visualize the results of queries on historical data.

4. Implementing Robotic-based BI applications: The multiplicity of actors in IoRT systems in smart farming makes the implementation of the system difficult, since all actors must obtain a system that respects individual needs. To solve this problem, MDA is utilized to permit actors to define their needs without focusing on implementation details, and also permits the automatic generation of the code.

The proposed approaches were tested to show their validity in different case studies in the smart farming context, namely:

1. The proposed UML profile for modeling smart sensors [1] was validated theoretically, showing its effectiveness to be adopted for smart IoT applications. Also, an implementation of smart sensors is performed, showing that smart sensors changes their sending/sensing policy when the temperature exceeds a threshold.

2. The proposed UML profile [2] was tested, showing its effectiveness in handling name/type variability, complex objects, and extensibility. In addition, OLAP queries were performed on the data warehouse where robots' data is stored, showing the ability to perform queries over these complex data types.

3. The results of the preliminary tests [3] made with some real users show that stream tables are a valuable instrument for the elicitation of continuous queries, and that the fast prototyping tool helps in effective support to the specification and validation steps.

4. The proposed MDA approach [4] was tested in a real case study regarding robots. The approach uses the different abstraction levels of MDA and generates an automatic code ready to be deployed in IoRT devices. In addition, the approach showed its utility in reducing coding time significantly and the number of errors.

Keywords: IoRT, IoT, Robots, Sensors, UML Profile, Model-Driven Architecture, Business Intelligence.