Internet of Things (IoT)-Based System for Classroom Access Control and Resource Management (SISGERA)

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Technical State University of Quevedo, and University of Granada

Córdoba, November 2022

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On behalf of the authors and on my own behalf, I am pleased to address you to present this work entitled Internet of Things (IoT)-Based System for Classroom Access Control and Resource Management (SISGERA).

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Introduction

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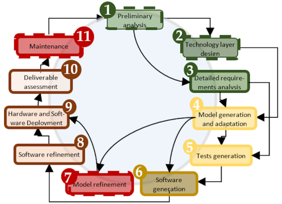
Introduction

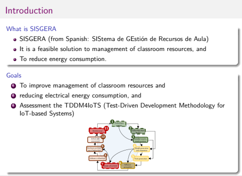
What is SISGERA

- SISGERA (from Spanish: SIStema de GEstión de Recursos de Aula)
- It is a feasible solution to management of classroom resources, and
- To reduce energy consumption.

Goals

1. To improve management of classroom resources and
2. reducing electrical energy consumption, and
3. Assessment the TDDM4IoTS (Test-Driven Development Methodology for IoT-based Systems)





In this work we propose to SISGERA from Spanish: SIStema de GEstión de Recursos de Aula. SISGERA is a prototype of an IoT-based system that was developed following the Test-Driven Development Methodology for IoT-based Systems, as a possible and feasible solution to manage classroom resources and to control access to classrooms. Therefore, the present work has a three goals.

The **first goal** Classroom resource management aims to ensure that classroom resources are switched on for the required time.

And as a consequence, **the second goal** reduce energy consumption. And **last goal** evaluate the TDDM4IoTS.

TDDM4IoTS is a methodology consisting of 11 phases, namely: Stage 1 Preliminary analysis, 2 Technology layer design, 3 Detailed requirement analysis, 4 Model generation and adaptation, 5 Test generation, 6 Software generation, 7 Model refinement, 8 Software refinement, 9 Hardware and software deployment, 10 Deliverable assessment, and 11 Maintenance. It addresses the construction of IoT device and development of both the software for IoT hardware configuration and the software for user interaction.

Goal (1): Improve management of classroom resources

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Goal (1): Improve management of classroom resources

Goal (1): Improve management of classroom resources

Classroom resources

Current challenges

- The janitorial staff is in charge of opening the doors.
- Each janitorial staff member must control access to approximately 16 classrooms.
- On some days of the week, all classrooms start classes at the same time.
- The professor must record student attendance.
- The professor does not know all his students (at least for the first few class meetings).

Other challenges

- The professor and students may leave the classroom at any time (e.g., when they need to move to practice labs).
- The professor does not have access to the remote controls of the devices.

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The janitorial staff is in charge of opening the doors of approximately sixteen classrooms at the beginning of the shift in the morning and closing them at the end of the shift in the afternoon. They to managing the door locks, they are in charge of the remote controls to manage projectors and air conditioners, so they turn these on at the beginning of the shift and expect to turn them off at the end of the shift.

It is a rule that the classroom must be opened when the professor is ready to enter, which can be a delay or rush for the janitorial staff, as one day all classrooms will be required at the same time by the respective professors to start classes.

When classes start, the professor must register the student's attendance, and from the very first classes, students may be evaluated on their performance, and the professor does not always identify each student, which may lead to some impersonation.

Goal (2): Reducing electrical energy consumption

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Reducing electrical energy consumption...

Example classroom FCI-008 class schedule

Start time to End time	Monday	Tuesday	Wednesday	Thursday	Friday
07:30 –0830					
08:30 –09:30	ME9MC1	ME9MC3		ME9MC6	
09:30 –10:30					ME9MC4
10:30 –11:30	ME9MC2	ME9MC4	ME9MC5	ME9MC2	
11:30 –12:30					
12:30 –13:30		EE8MC3	EE8MC1		EE8MC5
13:30 –14:30	EE8MC1				EE8MC4
14:30 –15:30				EE8MC3	
15:30 –16:30	EE8MC2	EE8MC4	EE8MC5		EE8MC6
16:30 –17:30				EE8MC6	

Reducing electrical energy consumption...
Example classroom FCI-008 class schedule

The SISGERA is implemented in a classroom at the Faculty of Engineering Sciences FCI. Some courses of its programs have practical hours -laboratory or field- and theoretical hours.

As an example of a classroom use schedule, we provide below the morning shift schedule of the classroom, which is used to teach the ninth module of the Mechanical Engineering degree, is show in green.

However, lessons are given for the eighth module of the Environmental Engineering degree in the same classroom during afternoon shift, which is shown in yellow. The blank spaces show that the classroom is free at that time.

Time without using the equipment

As the travel time that professors need to go to the corresponding classroom is between 5 and 15 minutes, the time that lights, air conditioners and video projectors will remain on without use will be between 10 and 105 minutes per day.

Reducing electrical energy consumption...

Time without using the equipment

The **professor:**

- The afternoon shift does not always start as soon as the morning shift ends.
- Plans the hours of laboratory practice.
- Manages class time (theory and practice).
- May not teach in the classroom.
- May leave the lights off.
- May leave the door opened.

Reducing electrical energy consumption...
Time without using the equipment
The **professor:**
- The afternoon shift does not always start as soon as the morning shift ends.
- Plans the hours of laboratory practice.
- Manages class time (theory and practice).
- May not teach in the classroom.
- May leave the lights off.
- May leave the door opened.

Not to mention the days when students finish their morning classes before the afternoon classes start, for example Monday, Thursday and Friday. That maybe cause lights and equipment to remain on for hours unnecessarily. In addition, the professor plans the hours of laboratory practice, and he/she manages class time theory and practice. In practice time the students have classes in computer labs, applied physics labs or other environments depending on the program, they must leave their usual classrooms, which implies the devices and even the lights could remain on unnecessarily. Our proposal aims to avoid this waste of energy, while extending the lifetime of devices and lamps.

Goal (3): Evaluation of the development methodology

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Goal (3): Evaluation of the development methodology

SISGERA (**SIS**tema de **GE**stión de **R**ecursos de **A**ula)

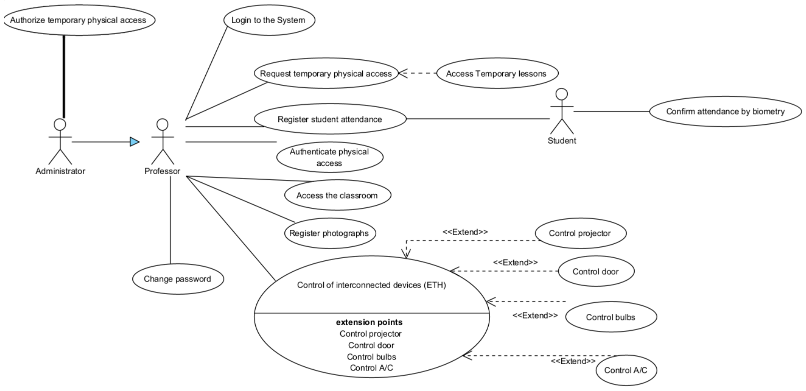
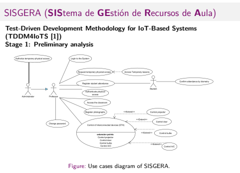


Figure: Use cases diagram of SISGERA.



Preliminary analysis **Functional requirements** Among the main requirements to be met by SISGERA are:

- Control devices: Turns on and off the lights, air conditioner and video projector.
- Physical access control: Verifies the identity of professor through facial recognition, and Unlocks the door to allow the professor to enter.
- Records student attendance by means of RFID identification.
- Verify the identity of students by fingerprinting.
- Unlock the door to let in students arriving after the start time.

Non-functional requirements Regarding the non-functional requirements of the system, it was determined that, as it is a system to be deployed in a classroom, the power supply is guaranteed by the public utility. As for the Internet connection, a permanent Wi-Fi connection is available.

Preliminary analysis - feasibility study

Technological feasibility: IoT hardware

- Raspberry Pi;
- Arduino Mega;
- infrared sensors;
- an IP camera;
- an RFID card reader and RFID cards;
- a fingerprint reader;
- a motion sensor; and
- relay modules.

Preliminary analysis - feasibility study
Technological feasibility: IoT hardware
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- relay modules.

All the IoT hardware components necessary to meet the functional requirements exist, and were within our reach.

- Raspberry Pi: for local processing and sending data via Internet.
- Arduino Mega: to treat the signals captured by the sensors and send the data to the Raspberry Pi through the Bluetooth module.
- infrared sensors: turn on and off air conditioner and video projector.
- an IP camera: to recognize people through live video.
- cards and RFID card reader: to identify students when accessing the classroom.
- a fingerprint reader: to identify students more securely when required.
- a motion sensor: to detect people presence inside the classroom; and
- relay modules: to turn on and off lights and equipment.

Preliminary analysis - feasibility study

Technological feasibility: Software tools and technologies

- Python language
- Java language
- Application server (GlassFish or Apache Tomcat)
- PostgreSQL

Economic feasibility

SISGERA is an inexpensive IoTS, it was fully funded by the project team, and its cost was within the expected budget.

Operational feasibility

SISGERA is intended to be easy to operate.

- RESTful web services will be created to store and retrieve the data in the database.
- The university has academic management systems, which can provide the data to SISGERA.

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In addition, in technological feasibility have the software tools and technologies

- Python Language: to facial recognition with OpenCV. Runs on Rapsberry PI
- Java langauge: to construct the Mobile app and Web Services RESTfull
- SISGERA was tested with GlassFish as the application server
- PostgreSQL: Persistence layer

Economic feasibility
SISGERA is an inexpensive IoTS, it was fully funded by the project team, and its cost was within the expected budget.
Operational feasibility
SISGERA is intended to be easy to operate. RESTful web services will be created to store and retrieve the data in the database. The administrator will be able to take photographs of professors for facial recognition, and also feed the system with student and academic planning data.