DIGITIZING PRODUCTS:
CREATING DEMONSTRATORS
FOR FUTURE EDUCATION

digi demo

Smart Lighting System

Demonstrator documentation

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ESTA Belfort

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Project consortium

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Dissemination level

Code	Access granted to	
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Legal Disclaimer

About the DigiDemo project

Environmental challenges and digital transformation are two of the main drivers changing the world and the way business will be is done in the future. Therefore, it is essential to enable future employees to address these drivers. The skills and competences needed to develop digitalized products and awareness of the environmental challenges are therefore crucial for the European workforce and industry to continue being competitive in a future green economy and to maintain jobs across Europe.

The DigiDemo project addresses these challenges by developing demonstrators especially for higher education allowing to improve mainly mechanical engineering studies by integrating skills and competences allowing them to understand, develop and commercialise connected products. The results will be publicly available and can be used by every institution interested in integrating this type of training in their cursus.

www.digidemo-project.eu

Table of Contents

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Abbreviations

ESTA	ESTA Belfort (France)
FHV	Fachhochschule Vorarlberg (Austria)
FSV	Fagskolen I Vinius (Norway)
UCN	University College Nordjylland (Denmark)
UBB	Centrul Universitar UBB din Resita (Romania)
IoT	Internet of Things
SME	Small and Medium Enterprises

List of figures

List of tables

1 Introduction

The purpose of this demonstrator is the development of a **smart lightning system** by groups of students that allow to lighten a room depending on the time of the day, the activities in the room, the brightness of the classroom as well as the presence of the people.

A remote control of the final system shall be possible. The development of a “product-like” result including a mechanical development and prototyping may be added.

A final product may be an additional element to light switches in rooms.

Using this demonstrator contributes to reducing energy consumption while increasing comfort and security.

This topic has been chosen for the following reasons:

- It is a real case with direct use to the students’ environment that allows to apply connectivity and IoT/software design.
- The overall project can be divided in subprojects that can be used as demonstrators and will form a bigger system once combined.
- The demonstrator highlights how technology can contribute to reduce environmental impacts of daily live.

2 Overview

The key properties of the demonstrator are:

Table 1: Specification of key properties

Key Property	Value
EQF level	☒ 5 (Technician) ☒ 6 (Bachelor) ☐ 7 (Master) ☐ 8 (PhD)
Year of study	2 or 3 (Depending on the type of study programme and programming skills. The setup remains easy)
Domain	☒ Mechatronics ☒ IoT
Objective	☐ Demonstrate a functioning ☒ Development by students
Workload	3 ECTS
Keywords	Smart home, Light switch, remote control, WiFi; Arduino, programming

This IoT demonstrator aims at showing how to connect, interact, gather, and control data of a simple IoT object through a centralized control system. The objective of the system is to manage lightning in an educational building. This system must make it possible to control the light online in the various classrooms and work rooms or in any other building in which rooms are used intermittently.

The control can be done depending on external parameters such as

- Brightness in the room (mandatory)
- Presence of people (mandatory)
- Day of time (facultative)
- Agenda (facultative)

A light bulb shall switch on automatically or be able to be switched on. Students had the freedom to choose the parameters they implemented in their demonstrator.

The demonstrator consists of:

- an Arduino Uno Rev3 board (ATmega328P)
- a brightness detector
- a movement detector
- a relay
- a resistor

- cables
- liquid-crystal display (LCD) screen.

It is connected to a 220V energy source and steers an external lamp.

External input data from the sensors are treated by the Arduino controller to steer the relay allowing to switch on or off the light bulb while displaying specific information on an LCD screen.

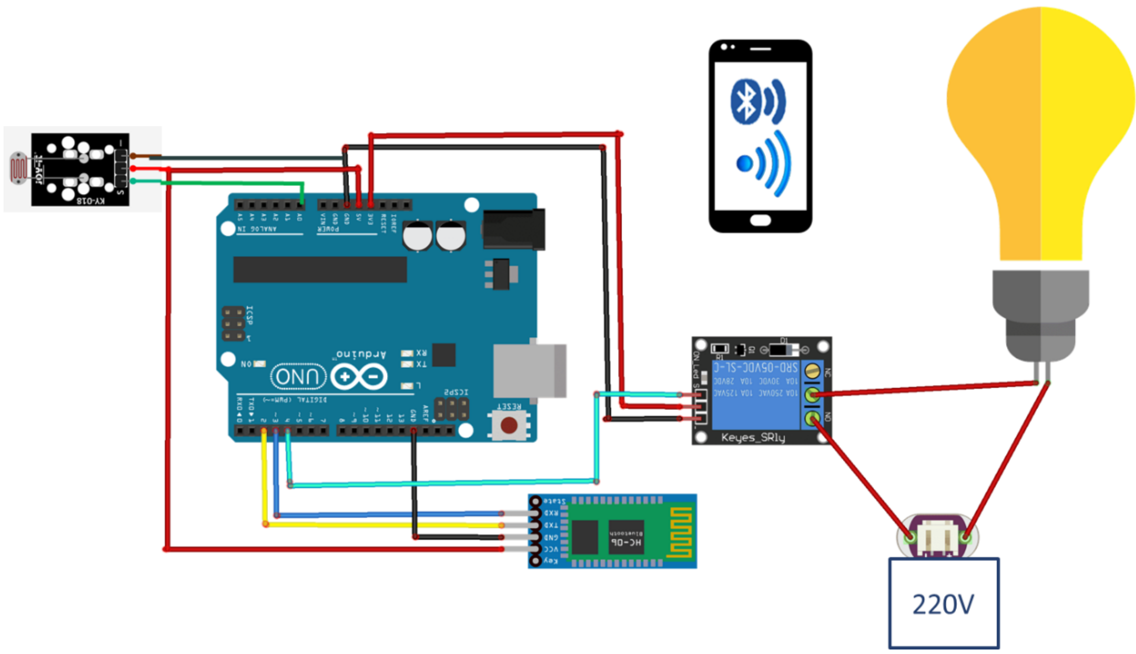

Figure 1 : Example of the schematics of a smart lightning demonstrator

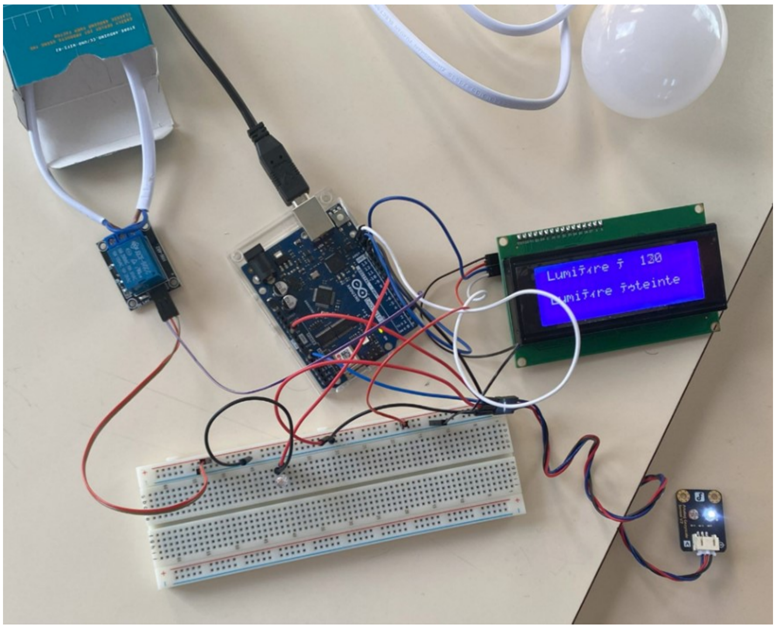

Figure 2 : Smart lightning demonstrator in situation

3 Description of fulfilment of demonstrator characteristics

This description shall be included as a table as shown below:

Table 2: Description of fulfilment of demonstrator characteristics

Characteristic	Description
Teaching improvement	The demonstrator enables students to think across pedagogic borders: ❖ Electrical: Selection of necessary electrical components and the set-up of the electronic circuit ❖ Programming: Development of the software code to steer the Arduino micro controller and to enable the system to communicate with an external device (e.g., Smartphone) ❖ Mechanics: (optional): The miniaturization, development, and prototyping of a full working product that can be used in a class
Sustainability awareness	The product itself contributes to energy reduction and raises awareness about unnecessarily switched on lights. The standard of-the-shelf components used for the development of the demonstrator can easily be disassembled and reused in the next class.
Replicability	The demonstrator is developed by students using standard electronical elements, it can easily be replicated.
Industry needs	Adding (autonomous) smart lightning systems in all buildings will allow avoiding lights being switched on when there is no need. There should be a huge market for this type of product.
Interdisciplinarity	The demonstrator needs electrical and programming skills as well as, if a full functioning product shall be developed, mechanical competences

4 Classification according to the dimensions

Table 3: Classification according to the dimensions

Dimension	Property	Value
Value chain	development	☒
	production	☐
	sales	☐
	after-sales-support	☐
	use	☒
	end-of-life	☐
Chain of technology	mechanical structure	☐
	sensors	☒
	electronic circuits	☒
	edge device	☐
	data transmission	☒
	cloud	☐
Sustainability	energy reduction	☒
	material reduction	☐
	better materials	☐
	better production	☐
	reparability	☐
	recycling	☐
Physicality	physical setup	☒
	simulation	☐
Degree of student freedom	demonstrated	☐
	guided	☐
	coached	☒
	autonomous	☐
Transportability	fixed	☐
	transportable	☐
	portable	☒
Costs (implementation)	EUR	100
Costs (operation)	EUR	5

Dimension	Property	Value
Workload (implementation)	Hours – Teacher Hours - Students	24 30 each
Workload (operation)	Hours	N/A
Size	m	20x30x20
Weight	kg	< 1
Special requests	no/yes, if yes: which	no

The costs are mainly linked to the reusable electronic elements.

5 Educational information

5.1 Prerequisites

- Notions of electronic
- Notions of programming,
- Notions of networks
- Notions of data management
- Intensity and voltage of an electrical circuit

5.2 Course content

I. Introduction

- The emergence of IoT;
- Definitions and concepts;
- IoT models and principles;

II. Basic hardware elements for IoT

- Electronic components, sensors, microcontrollers;
- Development boards: Arduino, Raspberry Pi;

III. Programming for IoT

- C/C++ programming with Arduino;
- Python and JavaScript (NodeJS) programming with Raspberry Pi;

IV. Internet, networks, and communication protocols for IoT

- Architectures, networks, and key protocols for IoT;
- OSI model, IPv4/IPv6, TCP/IP, UDP, DNS, HTTP, MQTT, CoAP, Lora, LoraWAN;

V. Data storage and analysis for IoT

- Databases for IoT, SQL/NoSQL, APIs, REST;
- Statistics and analysis of data and time series;

VI. Key application domains of IoT

- Monitoring and control interfaces for IoT systems;
- Components of an IoT application; Web of Things;
- Challenges and limitations.

5.3 Course result

The student will be able to apply knowledges in a diversified context, allowing the aggregation and integration of the variety of technologies into a coherent system for IoT.

He/she will be able to:

(1) identify the elements of an IoT system,

(2) know the role of the constituent technologies of an IoT system, and

(3) use the specific and adapted tools allowing the design, development, and prototyping of systems for IoT.

5.4 Planned learning activities and teaching methods

The course extends over a duration of 40 hours per student in face-to-face sessions and 15 hours of independent work, totalling 55 hours. The pedagogical methods used are experiential learning and project-based learning.

The individual project work receives personalized supervision for 15 hours (distributed according to the total number of students) and an additional 15 hours of independent work.

Course Composition:

- Lectures (in-person) - 10 hours
- Tutorials (experiential learning) - 15 hours
- Individual Project (personalized supervision) - 15 hours
- Project Independent Work - 15 hours

5.5 Evaluation methods and criteria

The evaluation will focus on the following aspects:

- Written exam grade: key concepts, exercises (30%)
- Evaluation of exercises in tutorials (20%)
- Grade for the individual Java project (50%):
- Maximum 10-page PDF report (10%)
- Presentation (10 minutes + 5 minutes of questions - 20%)
- Project source code (functionality, creativity, complexity - 20%)

Expected Deliverables:

- Individual project (source code, report, and presentation)
- Source code for the exercises evaluated in tutorials.

5.6 Sustainability – questions for reflection

The questions below are meant as inspiration for the teacher using the demonstrator. The aim is to strengthen the student's awareness regarding sustainability through reflecting upon questions related to the demonstrator. The questions can be used during the lecture or as the starting point for individual or group work, connected to the lecture. It is suggested that the students in groups answer the questions and then present the result of the discussion on class.

The questions below are divided into three main categories, general considerations, recycling, and product integrity, where the last two categories are addressing this specific demonstrator.

General considerations

- Does the making or use of the product create pollution?
- How can the energy consumption of the demonstrator be reduced?

Recycling

- Can the demonstrator, or parts of it be recycled?

Product integrity

- Can parts which should be maintained be easily disassembled from the demonstrator?
- Can an update of components (which?) be foreseen to enlengthen its lifespan?

6 Organizational information

For the organisation of the demonstrator the following applied:

- Project duration: Students had one semester to develop their demonstrator with a certain amount of freedom, especially with regard to the steering parameters they use (brightness, movement, time of day, external agenda…)
- Team size: Students worked in groups of two or three. The demonstrator was used by sales engineering students specialising in computer sciences, but having also complementary skills (sales, marketing, management but also basic knowledge in mechanics).
- Preparatory and follow-up activities: N/A

7 Description of the technology and the setup

7.1 Demonstrator Documentation

There is no manual for the demonstrator as each student's solution may differ slightly.

7.2 Price calculation

Details of the price calculation for a standard demonstrator set-up can be found in the table below (some parts not listed needed for specific solutions developed by students may become necessary).

Table 4: Price calculation of a standard Smart Lightning Demonstrator

Quantity (unit)	Description	Price (per unit) [€]	Price total [€]
1	Arduino Uno rev3 Board (Atmega 328P)	25,00	25,00
1	Movement detector	10,00	10,00
1	Brigthness detector	10,00	10,00
1	Relay	3,00	3,00
1	Resistor	1,00	5,00
20	Cables of various coulours	0,50	5,00
1	LCD Screen	20,00	20,00
1	Breadboard cartes	5,00	5,00
1	Light bulb holder	10,00	10,00
1	Light bulb	3,00	3,00
		Total	**96**