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Digital Transformation in Advanced Manufacturing

DTAM Teacher Training Manual



DTAM

DIGITAL TRANSFORMATION IN
ADVANCED MANUFACTURING

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1 What is DTAM?

The Digital Transformation in Advanced Manufacturing – DTAM project aims to create and provide innovative curricular training (reskilling and upskilling opportunities) in digital transformation competences for the advanced manufacturing sector, for mid-high level IT and OT technicians at EQF Levels 4-5 +. The DTAM partnership will design and deliver an innovative curriculum in key enabling technologies and transversal competences for AM. The integral DTAM curriculum will prepare:

- ICT technicians to approach and understand digital technology in relation to AM processes and machinery (how to install, configure and monitor cyber physical intelligence and tools in AM environments)
- Robotics and Automation (or other OT) technicians with the ability to understand and manage digitalization tools and the most advanced AM technologies for secure deployment and maintenance.

Materials delivered will allow technicians to understand, install, configure, monitor, analyze, transfer data and maintain digital systems in advanced manufacturing environments.

The complete DTAM curriculum will offer learners in IVET and CVET, and self-learners open access to all training modules as OERs via the project e-learning platform and to innovative supporting digital technology in the form of an international network of IoT labs. Innovation accessible to *training providers and learners* will include:

- A Digital Transformation Skills Index detailing the most relevant competences a technician in the AM sector will need for future employment
- A Self Evaluation of Technical/Digital and Transversal Skills Online Tool
- A series of Innovative Training Modules on digital transformation for AM covering: Big Data, Machine Learning, Sensors, Cyber-Security, Transversal Competences
- A DTAM IoT hub providing access to a developed IoT digital ecosystem for VET and adult learners; the ecosystem will consist of an initial partnership network of 4 remote DTAM IoT labs in Italy, Greece, the Netherlands and Spain accessible via the e-learning platform
- Methodological supporting tools for VET staff: clear learning outcomes for each module and unit of learning, innovative methodological content and guidelines, evaluation and accreditation guidelines based on ECVET and ECTS principles, and course certification.

The partnership will encourage the growth of digital transformation, and talent and technology 4.0 profiles in H/VET centers by providing and launching a(n):

- Model for the Creation and Exploitation of a Sustainable IoT lab.
- International Network of DTAM IoT labs.

2 The Digital self evaluation tool

2.1 General Description

The Digital Self Evaluation Tool is an online platform which will be available for those students who will participate in the future training and where they will know about their current skills. It is based on an interactive platform which includes several serious games which allows to measure several hard and soft skills from the students, such as:

- Self learning
- Problem Solving
- Communication and Cooperation
- Leadership
- Information and Data Analysis
- Project Management
- Flexibility - Critical Thinking
- Globalization - Intercultural Communication

This is the first phase of the students that will be participating in the training. They will be able to measure the soft skills from above but also the hard skills in order to check their current level and select the intensity of training for the rest of the modules developed in the learning platform. Once completed, each student will receive the results of their testing.

2.2 Platform Access

Professors have their own access to the back office of the self-evaluation tool. In the back-office, professors will be able to create processes, send them to certain students, check results and edit information.

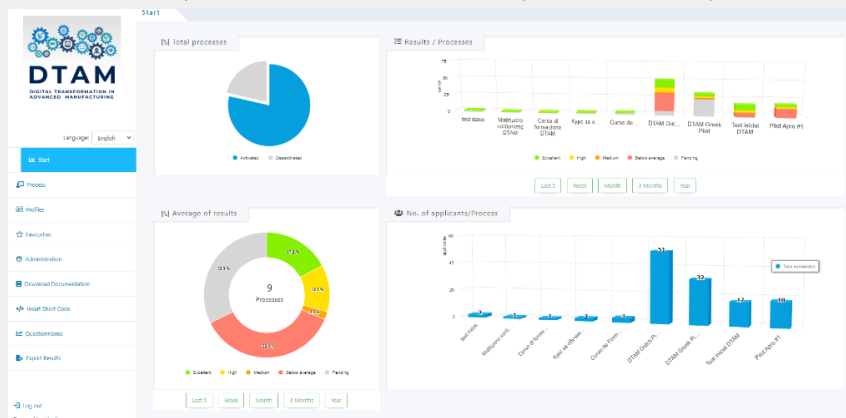
Link to platform: <https://dtamproject.gestionetdev.com/auth/login>. Each training institution has its own access to the back office.

2.3 Structure

2.3.1 Home

This is the home page that the user will be able to see once they access the platform through the link provided. There is a summary with general statistics of all processes performed. There is the main menu of the platform with a clear user-friendly interface.

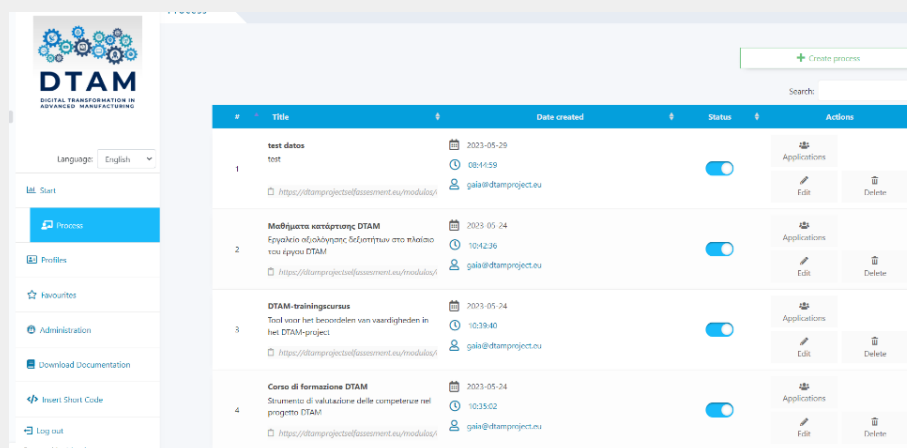
The results of the active processes can be filtered by week/month/year, etc.



2.3.2 Process

In this section, professors will be able to:

- Create an open or closed process.
- Access to all the processes created in real time.
- Access to the reports.
- Edit processes.
- Forward a created process to more candidates.



The screenshot shows the DTAM Process management interface. It includes a sidebar menu similar to the home page. The main area has a '+ Create process' button and a search bar. Below is a table listing processes:

#	Title	Date created	Status	Actions
1	test datos test https://dtamproject.eu/assessment.eu/module/	2023-05-29 08:14:59 gala@dtamproject.eu	Active	Applications, Edit, Delete
2	Μαθήματα κωδικοποίησης DTAM Εργαλείο αξιολόγησης δεξιοτήτων στο πλαίσιο του έργου DTAM https://dtamproject.eu/assessment.eu/module/	2023-05-24 10:42:36 gala@dtamproject.eu	Active	Applications, Edit, Delete
3	DTAM-trainingcursus Tool voor het beoordelen van vaardigheden in het DTAM-project https://dtamproject.eu/assessment.eu/module/	2023-05-24 10:39:40 gala@dtamproject.eu	Active	Applications, Edit, Delete
4	Corso di formazione DTAM Strumento di valutazione delle competenze nel progetto DTAM https://dtamproject.eu/assessment.eu/module/	2023-05-24 10:35:02 gala@dtamproject.eu	Active	Applications, Edit, Delete

2.3.2.1 Applications

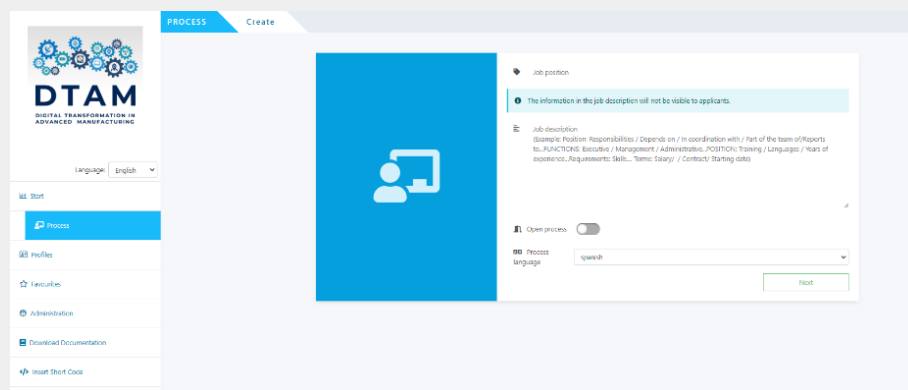
Within each of the process, there are accessible the applications done by students with its results and there the user can:

- View the status of all applications in real time.
- Access the reports of the results obtained per participant.
- Download the results of the process to excel.
- Compares quantitatively and graphically the results obtained with the desired results according to the collective.



2.3.2.2 Creating a process

In order to create a testing process, it just has to click on “create process” and then activate the desired modules for the process to be created (Tests, Video Interview, Data, Hard Skills). Once selected the modules that the process will follow, it can be sent to users, by just adding the email of all the candidates that will get the link to evaluate their hard and soft skills.

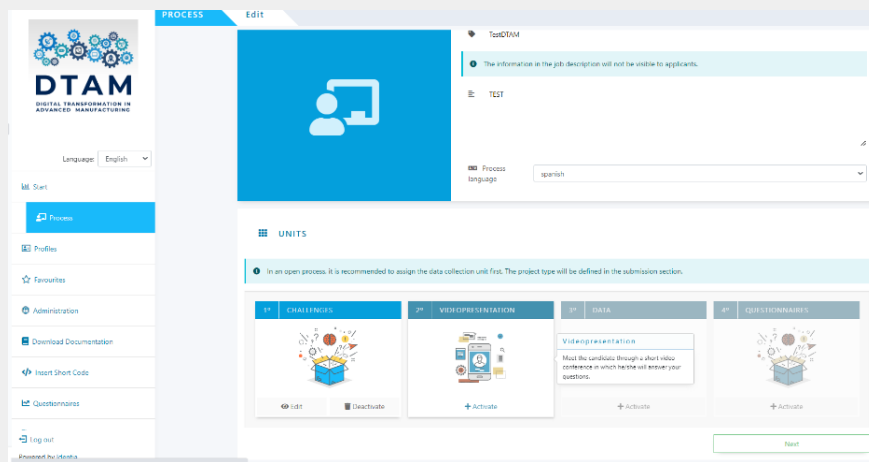


Once created a process, the user can access all the information obtained from the candidate in each of the module and will be able to check the percentage of the process already performed:

- Data module with information of candidates
- Evaluation results of the soft skills
- Video interview
- Hard skills results with the different modules.

2.3.2.3 Creating hard skills module and video

A module for creating questionnaires to measure the hard skills is available. It can be evaluated by classifying the questions into 5 different categories. In this one, the user just needs to create the questions in the platform and add the different multiple choice options which will appear to the student.

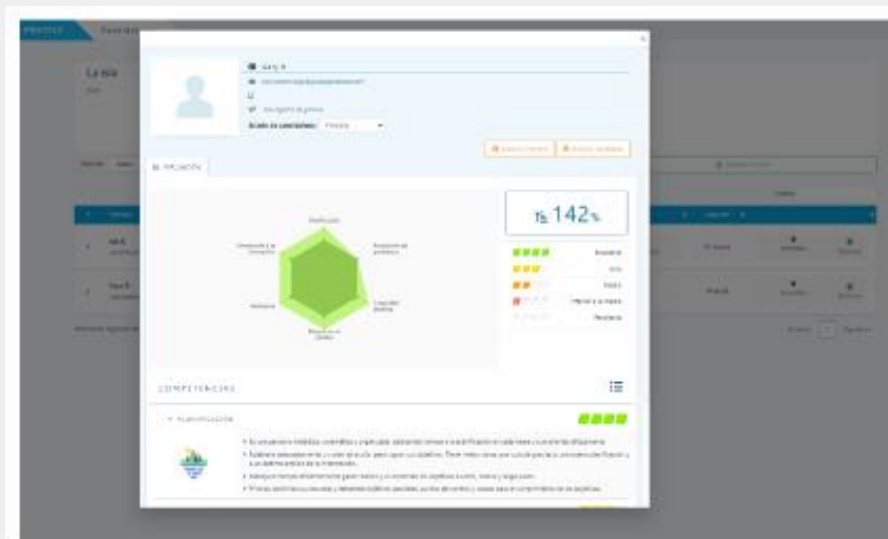


In the case of the video that will help to measure the global communication soft skills, the professor just needs to add the questions to be addressed to the students and include how much time they will have to answer them.

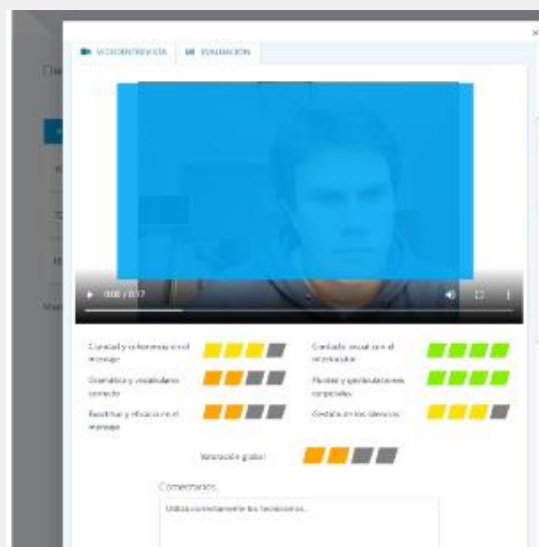
2.3.2.4 Candidate reports: Evaluation modules

The report of results is visual and user-friendly, easily interpretable. It combines qualitative and quantitative information. Each of the students that has participated in the process, will have its own evaluation which includes qualitative and quantitative information for the hard skills and soft skills measuring.

In the hard skills modules the user can view the results and evaluate by classifying in different categories.



In the video interview module, the user can view a 2-minute recording of the candidate answering customized questions. It allows assessment and evaluation while viewing the recording, scoring verbal and non-verbal communication through accurate KPIs. Once answered, the professor will need to evaluate and rate the answers of each of the participants. The platform allows it



2.4 Testing by students

Students will receive an email to access the tests that have been assigned to the project:

Hard skills tests

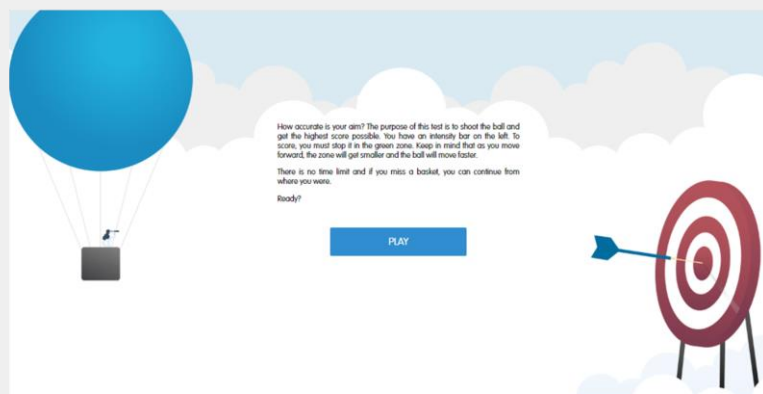
The first module is a hard skills test. There are 33 questions about technical skills that has been prepared by project team in order to measure the knowledge of students in the different modules of the training:

- Big Data
- Machine Learning
- Advanced Sensorica
- Cybersecurity

Professors can adapt, change and add questions whenever needed through the back-office.

Soft Skills

1. **Basketball game:** In this first game the user will play and the objective is to score as many times as possible. The game begins with an easy level but becomes more difficult. It measures Flexibility - Critical Thinking



2. **Island:** Second game is a longer one (about one hour) which consists of an island that the user will need to manage. The candidate is placed as the manager of an island, where he/she will have to make multiple decisions to improve the conditions of its inhabitants. They will have certain resources and processes and will need to understand and apply the logic. The soft skills to be measured are: Self learning , Problem Solving, Communication and Cooperation, Leadership, Information and Data Analysis, Project Management. Before starting, there is a tutorial explaining the game.

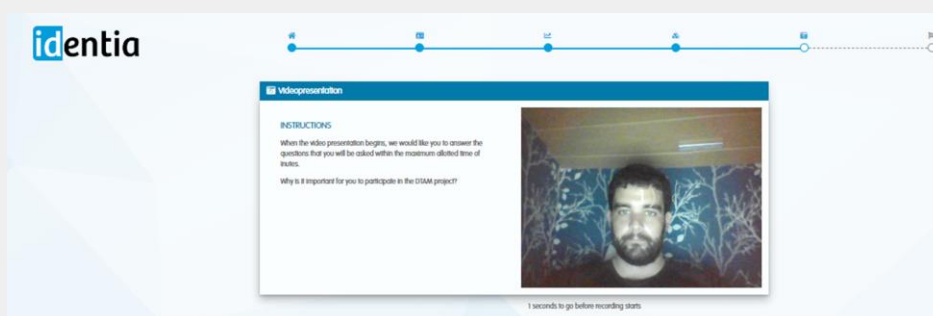


The game consists of 5 turns where the user needs to make decisions about the management of the island and will get results after each of those turns. Then they will need to take new decisions to adapt/improve island management

It is an experience composed of cases of varying complexity and with weighting of each of the competencies so that the assessment is fully aligned with the priorities of the client (company and selected position).

Psychometrics, algorithms, machine learning and Big Data make this solution a unique test.

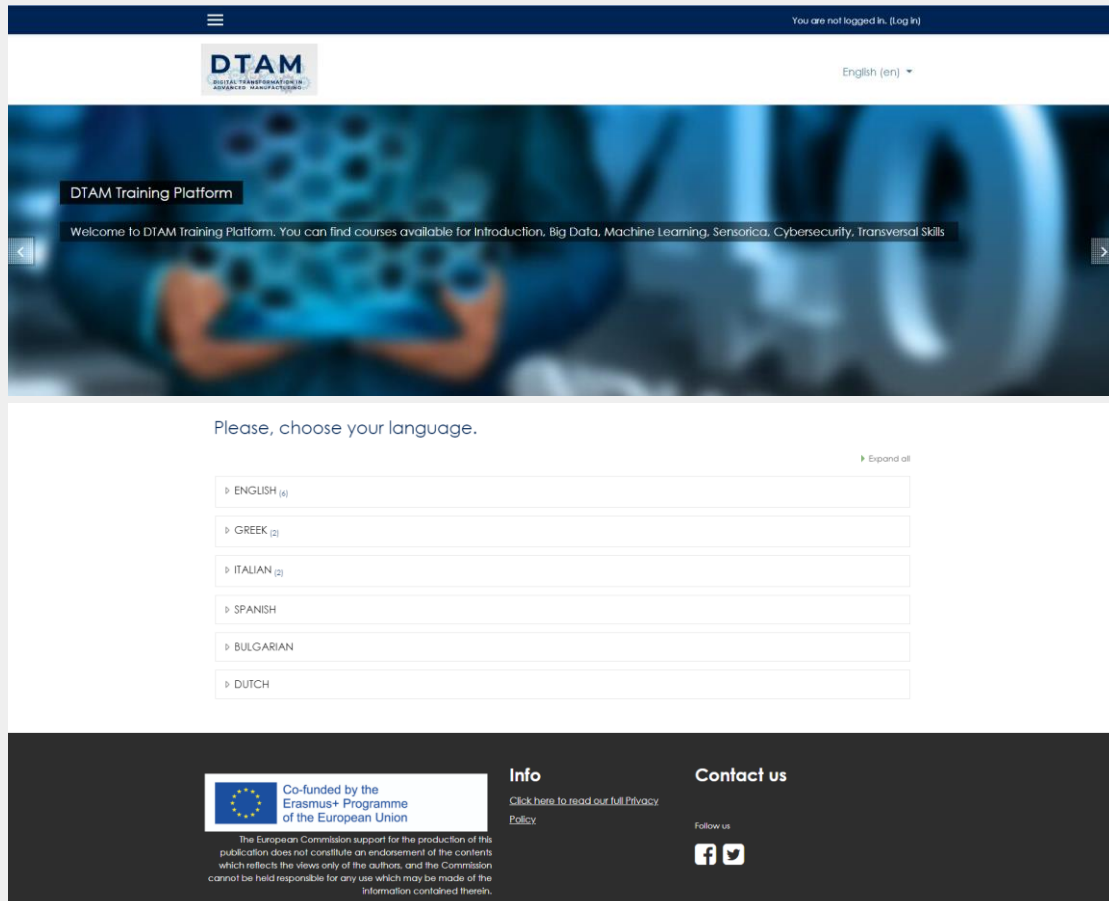
3. **Interview:** there will be a small interview which will allow the users to respond to some questions about globalization and intercultural communication. Professors are able to change questions and select how much time students have to respond. At the end the project team will be able to value each of the students based on criteria selected.



After all tests are performed, the results will be available on the platform and all partners will be able to check them. Besides, the students will also get results and will be able to know the information of their process.



3 The Learning Platform



DTAM Training Platform

Welcome to DTAM Training Platform. You can find courses available for Introduction, Big Data, Machine Learning, Sensorica, Cybersecurity, Transversal Skills

Please, choose your language.

Expand all

- ENGLISH (6)
- GREEK (2)
- ITALIAN (2)
- SPANISH
- BULGARIAN
- DUTCH

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3.1 How to use the Platform

3.1.1 Requirements

The only requirements for entering the DTAM Platform are a computer and an Internet connection. The link for the platform is as follows: <https://e-training.dtamproject.eu/?redirect=0>


Login

Once you enter the platform, you need to create new account

DTAM Online Training Platform

☐ Remember username


[Forgotten your username or password?](#)

Cookies must be enabled in your browser 

Some courses may allow guest access

Is this your first time here?

For full access to this site, you first need to create an account.




Then a form for submitting your details will be requested.

DTAM Online Training Platform


New account

▼ Collapse all


▼ Choose your username and password


Username 


The password must have at least 8 characters, at least 1 digit(s), at least 1 lower case letter(s), at least 1 upper case letter(s), at least 1 non-alphanumeric character(s) such as *, -, or #


Password 

▼ More details

Email address 

Email (again) 


First name 

Surname 

City/town

Country

[Create my new account](#) [Cancel](#)

There are required fields in this form marked .

After filling the required fields, you must click on the blue framework: **“Create my new account”**, you will receive a link in your email and click on it to confirm your registration. In order to login to the platform you must type your credentials in the following boxes and click on the Login button.

DTAM Online Training Platform

☐ Remember username

[Forgotten your username or password?](#)

Cookies must be enabled in your browser ?

Some courses may allow guest access

←

Login Button

Is this your first time here?

For full access to this site, you first need to create an account.

If you have successfully logged in, you will be able to see your Dashboard. In this page, you can find a list of all your registered courses and their status. Then you click on the site home to enter the courses.

Dashboard

Site home

Calendar

Private files

DTAM

Recently accessed courses

No recent courses

Course overview

▼ All (except removed from view) ▼

Course name ▼ Card ▼

No courses

Click here to see the courses

←

In this page you can see all the available language and select the preferable one.

Please, choose your language.

[▶ Expand all](#)

▷ ENGLISH (6)

▷ GREEK (2)

▷ ITALIAN (2)


▷ SPANISH

▷ BULGARIAN

▷ DUTCH


3.1.2 Course Selection

To select the course you want to study, just click on the course name and you will be transferred to the corresponding page.




Introduction

The introduction module helps students to refresh or acquire the minimum skills required to start DTAM course. Here you can find fundamental skills about PC Systems and Raspberry Pi, Networking, Python programming, Databases, Electronics and Sustainability....



Transversal Skills

This course is for technicians and professionals who would like to access and improve learning process on a different and pioneering way. At the end of the module, on a personal level you will have the ability to achieve individual learning, adapt on different situations, find innovative ideas and surpass difficulties. It is well known that a strong and complete personality L...




Cybersecurity

Upon completion of the module the student will be able to:


- Understand which is the level structure of an Industrial Control System (ICS).

Teacher: Jokim Goioaga




Sensorica

Teacher: Peter Snoek
Teacher: Francien van Kan



Machine Learning

This course is an introduction to Machine Learning and includes key concepts. Learners will be able to implement machine learning applications end-to-end in Python following defined steps and choose appropriate Python library depends on the problem that needs to be solved....



Big Data

This course is for technicians and professionals who would like to understand the core tools used to wrangle and analyze big data, as well as the core tools used for distributed processing of large data sets across clusters of computers. Although the tools that are presented are generally applicable for data processing, analysis and visualization, the module is mainly...

Introduction



The introduction module helps students to refresh or acquire the minimum skills required to start DTAM course. Here you can find fundamental skills about PC Systems and Raspberry Pi, Networking, Python programming, Databases, Electronics and Sustainability.

Transversal Skills



This course is for technicians and professionals who would like to access and improve learning process on a different and pioneering way. At the end of the module, on a personal level you will have the ability to achieve individual learning, adapt on different situations, find innovative ideas and surpass difficulties. It is well known that a strong and complete personality is the first step on professional success....

Cybersecurity



This course is for technicians and professionals who would like to define and implement security strategies in industrial organizations and infrastructures. At the end of the module you will learn how to perform cybersecurity diagnostics, identifying vulnerabilities and implementing the necessary measures to mitigate them, applying the necessary measures to mitigate them by applying the current...

Teacher: [Jokin Goioaga](#)

Advanced sensors



This course will introduce different sensors, devices to connect the sensors to data storage services, networking solutions and data processing solutions. The course involves working with Raspberry Pi's, Arduino's, NodeRed, Grafana, programming sensors using Python, and network communication over TCP/IP, Zigbee, LoRa, Bluetooth, 4G/5G cellular networks, 433MHz, and Z-wave. Data is sent to a MySQL...

Teacher: [Francien van Kan](#)

Machine Learning



This course is an introduction to Machine Learning and includes key concepts. Learners will be able to implement machine learning applications end-to-end in Python following defined steps and choose appropriate Python library depends on the problem that needs to be solved....

Big Data



This course is for technicians and professionals who would like to understand the core tools used to wrangle and analyze big data, as well as the core tools used for distributed processing of large data sets across clusters of computers. Although the tools that are presented are generally applicable for data processing, analysis and visualization, the module is mainly oriented for advanced manufacturing use cases...


3.1.3 Course Enrolment

For each course you choose, you have to enroll you, just click the button: “Enroll me”


Introduction

Dashboard / Courses / ENGLISH / Intro / Enrol me in this course / Enrolment options

Enrolment options

 Introduction

The introduction module helps students to refresh or acquire the minimum skills required to start DTAM course. Here you can find fundamental skills about PC Systems and Raspberry Pi, Networking, Python programming, Databases, Electronics and Sustainability.



Enrolment (Student)


No enrolment key required.

[Enrol me](#)
← Click here to register for the course


After that you will be transferred in the course (we have chosen “Introduction” course) page, and you will see the following page:

Introduction

Dashboard / My courses / Intro


 Announcements

PC & Raspberry Pi fundamentals

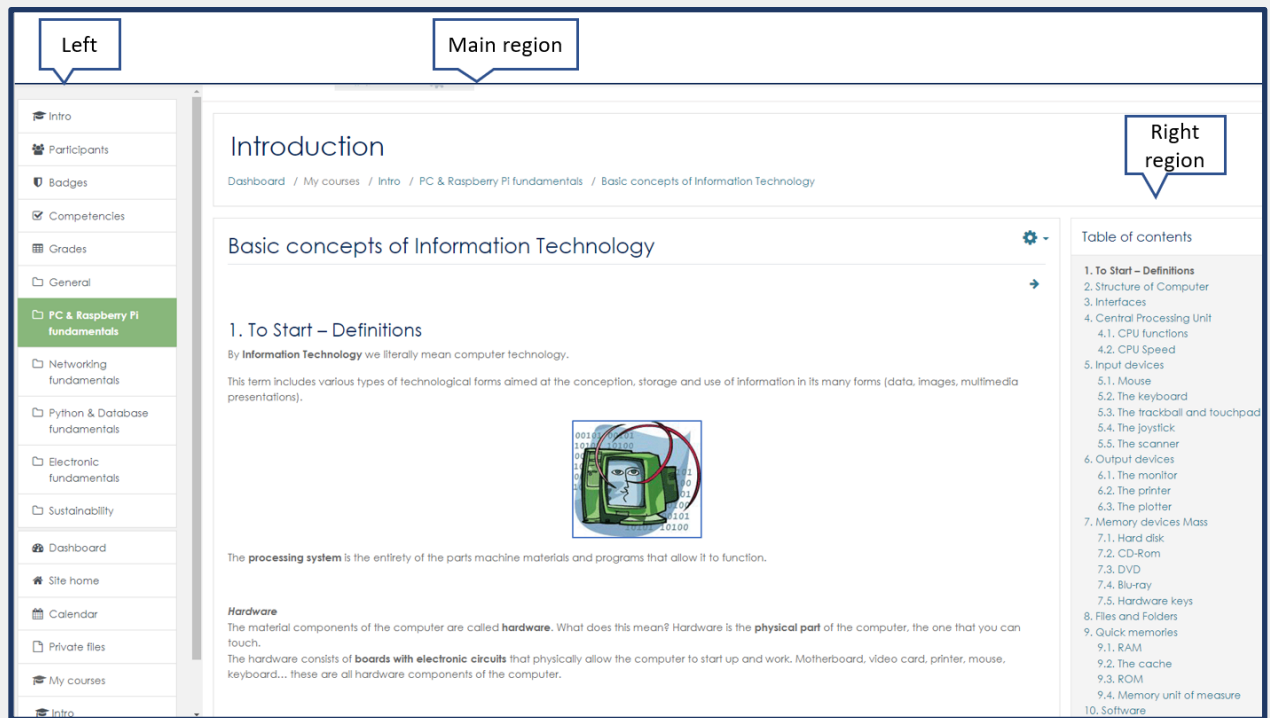


- Basic concepts of Information Technology
- Single Board Computer
- Quiz - PC & Raspberry

Networking fundamentals



3.1.4 Course Region Layout



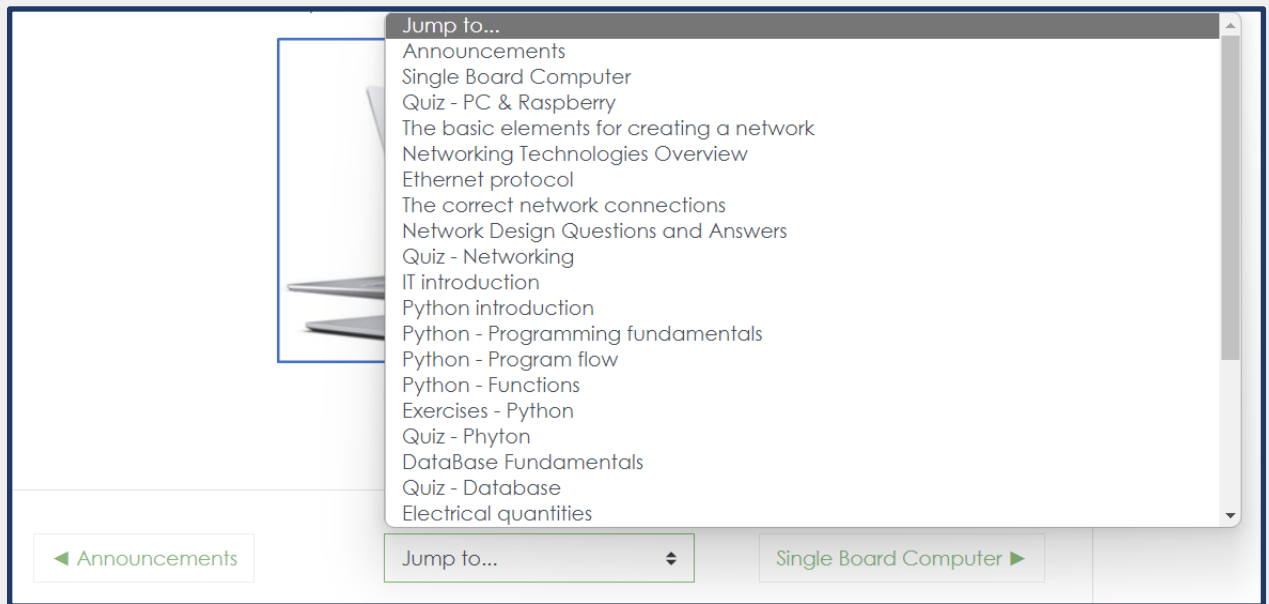
The course is organized in three regions:

- **Left region:** The left region has tools which will help you to navigate in the platform
- **Right region:** In the right region you can see a column with units and subunits (course structure)
- **Main region:** In the main region, you will find the course learning material which you must study.

Here you will find:

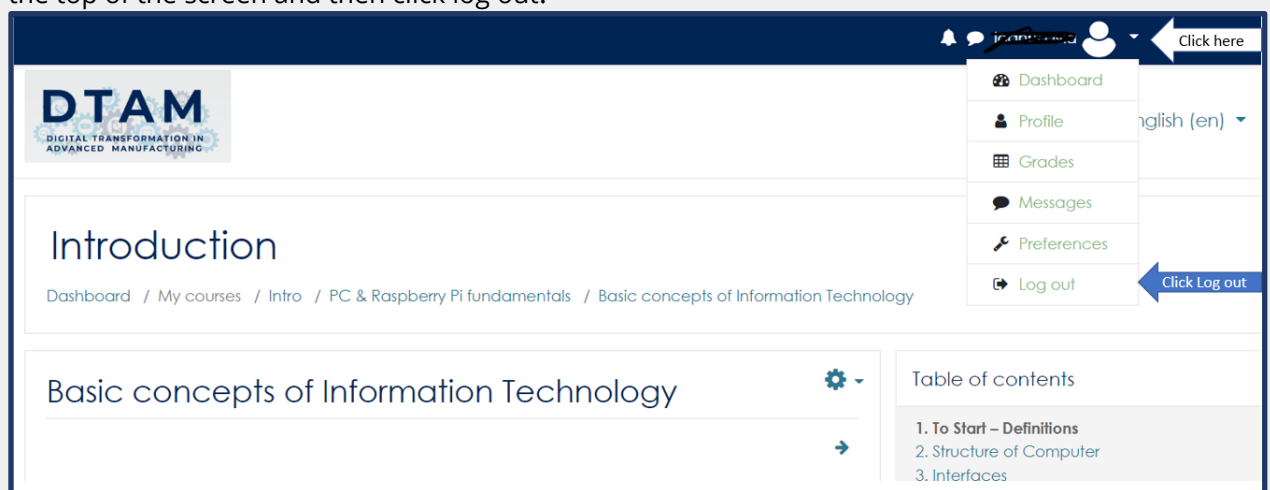
- The course name,
- Topics
- Quizzes
- Exercises
- General information about the course (if applicable)
- The course training material
- Announcements
- Jump to...

You can directly access the course contents, exercises, quizzes, subunits etc



3.1.5 Logout from the e-learning platform

In order to logout from the e-learning platform you should select the down arrow icon at the top of the screen and then click log out.



4 IoT Labs main features

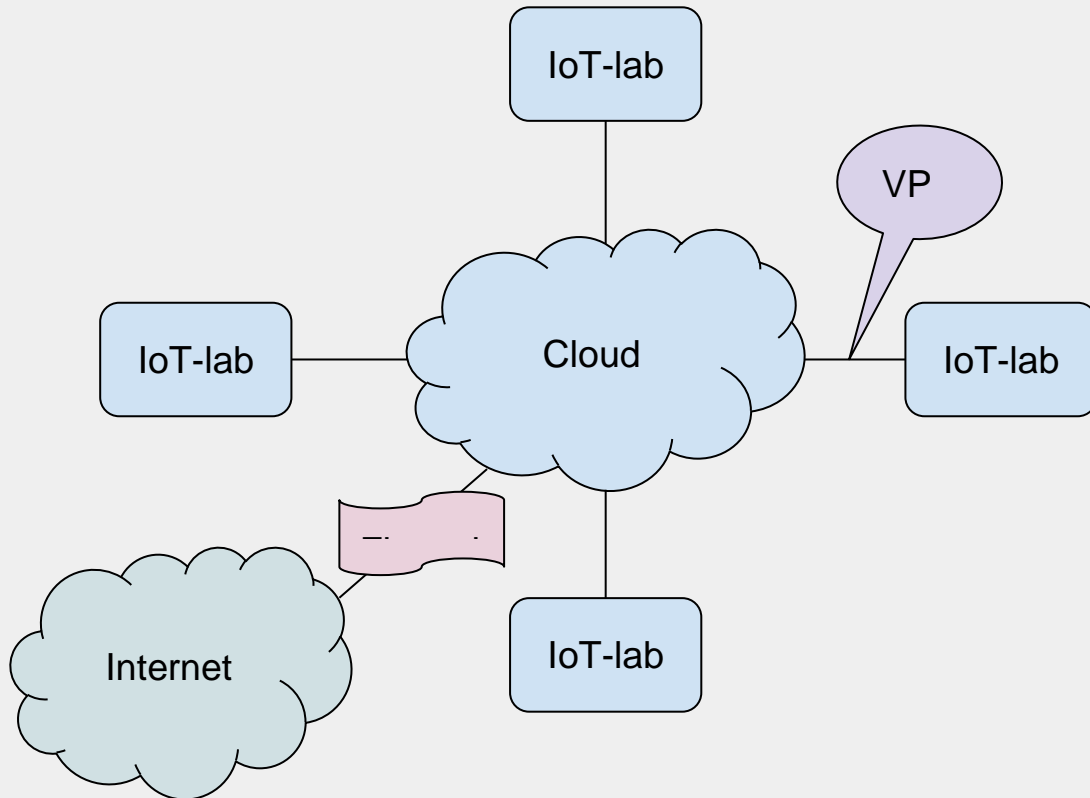
The project document “[Features of the DTAM IoT Lab](#)” describes the general structure of the lab, as well as a list of supported hardware and components.

It will start by describing the minimum setup required, while highlighting potential upgrades which would enable additional functionality. While the IoT-lab is designed to be the facility where the assignments can be performed, a lab is first and foremost an environment where one can experiment and learn. This means that also the lab itself is subject to change and development. It is therefore the hope and aim of the writer that the IoT-lab eventually becomes much more than just the basic setup described in this document.

These are the requirements for the IoT-lab

- All assignments from the different training modules of the DTAM curriculum can be performed in the IoT-lab
- The IoT-lab will be designed to accommodate a minimum of 10 students simultaneously, provided they work in teams of 2. This means that a minimum of 5 experimental setups need to be available.
- The IoT-labs will be connected to a central cloud, allowing for the exchange of data.
- Data will also be stored locally in each IoT-lab
- Necessary services will run locally in each IoT-lab to guarantee local availability in case of network or cloud problems.

The basic interconnection of the IoT-labs will be through a central cloud. The connections to the cloud will be over VPN, thereby securing all exchanged data and virtually joining all labs in one network. For security purposes, all network traffic will be routed through the VPN connections, even internet traffic. This means that the whole network of IoT-labs is only connected to the internet at one point, making it more secure and only dependent on the configuration of one firewall.



5 Training Module 1: Information technology and operational technology

5.1 General description

This training module aims to provide the learners with the basic knowledge and skills for information technology, as well as the operational technology. It provides an overview of IT systems, IT networking and electronic fundamentals. As Python is the programming language that is used through the DTAM curriculum, this training module also makes an introduction to programming with Python. At the end of the module, you will learn the basics of Information and Operational Technology that are essentials for the AM technicians.

5.2 How to use the training module

The aim of this training module is to complete or refresh the learners competences in order to start in the best way their works on DTAM Project.

The Digital Evaluation Tool gives to the learners an indication about their starting level and a suggestion of which are the compulsory learning units to complete before starting to work on DTAM.

5.2.1 Learning units and assessment

This training module is structured in five learning units:

- PC & Raspberry Pi fundamentals
- Networking Fundamentals
- Python & Database fundamentals
- Electronic Fundamentals
- Sustainability

At the end of each unit learners have to complete the assessment test, where several quizzes will evaluate the reached results. The quizzes are generally multiple choice type, with one or more correct answers, but there are also other kinds of tests as sentences to complete with proposed words or matches between lists or images.

Each quiz is considered passed if **at least 80%** of the answers are correct

5.2.2 Exercises

Some exercises are proposed in the training module, their execution needs only the materials available in the IoT lab. (ref. to the IoT lab section of the guide)

The exercises are not compulsory but warmly recommended to a complete understanding of the proposed arguments. The exercises evaluation is in charge of the teacher.

The proposed exercises are located in the following sections:

- Python & Database: programming exercises using Python applying the acquired knowledge about variables, functions and program flow management.
- Electronic Fundamentals: practical activities about drawing, construction and test of simple circuits applying electronic laws, basic components and measurement instruments.

5.3 Learning platform units: index

This training module is available in the platform structured in the following units and sub-units

- PC & Raspberry Pi fundamentals – 6h
 - Basic concepts of Information Technology
 - Structure of Computer
 - Interfaces
 - Central Processing Unit
 - Input devices
 - Output devices
 - Memory devices Mass
 - Files and Folders
 - Quick memories
 - Software
 - Single Board Computer
 - Raspberry PI
- Networking Fundamentals – 6h
 - The basic elements for creating a network
 - Ethernet topology
 - Client and server
 - Wiring
 - Network cards
 - Hub
 - Switch
 - Router

- Networking Technologies Overview
 - LAN Ethernet and Fast Ethernet
 - LAN Ethernet access and WAN
 - Virtual Private Network (VPN)
- Ethernet protocol
 - Gigabit Ethernet 1000BASE
 - IP Address
- The correct network connections
 - How to connect to the Internet
 - How to choose the Internet Service Provider
 - Elements of evaluation of an Internet Service Provider (ISP)
- Network Design Questions and Answers
 - How to spot congestion on the network
 - The 8020 rule
 - How to increase network performance
 - Short list of key networking components
- Python & Database fundamentals – 6h
 - IT introduction
 - Python introduction
 - How to start: basic working tools
 - Programming fundamentals
 - Math Operators
 - Variables
 - Boolean Variables and logic operators
 - Relation operators
 - Arrays
 - Program flow
 - If...else statement
 - Loops
 - Functions
 - Some built-in functions
 - Print function parameters
 - Custom functions
 - Recursive function
 - Database Fundamentals
 - Fundamental characteristics and functions of a database

- Types of databases
- Hierarchical databases
- Reticular databases
- Object databases
- Relational databases
- The elements of a databases
- The tables
- The masks
- The queries
- The reports
- Electronic Fundamentals – 6h
 - Electrical quantities
 - Voltage
 - Electric Current
 - Electric Resistance
 - Electric Power
 - Frequency
 - Fundamental laws
 - Ohm's law
 - Kirchhoff's current law
 - Kirchhoff's voltage law
 - Equivalent resistance in series
 - Equivalent resistance in parallel
 - Electronic signals
 - Analog Signal
 - Digital Signal
 - Analog-to-Digital (ADC) and Digital-to-Analog (DAC) Signal Conversion
 - Sensors & Actuators
 - The difference between Sensors and Actuators
 - Common sensors and actuators
- Sustainability – 6h
 - Sustainability of development: terminology, circular economy and green economy
 - Introduction to the concept of Sustainable Development
 - The economics of things and a sustainable approach to production
 - Circular Economy and Green Economy
 - The 2030 Agenda for Sustainable Development and the Green Deal
 - Conscious use of resources in technology sector: raw materials, waste and energy

- Technology and Sustainability
- Raw materials
- Sustainable waste management
- Energy & Life Cycle Assessment (LCA)

5.4 Learning Outcomes

5.4.1 Competences

After this training module successful completion, the learners will be able to:

- Recognize and use hardware components in a standard network system
- Examine, interpret and use the Internet Protocol Standard
- Operate with network communications
- Getting started with a personal computer system
- Apply basic electrical concepts in industrial automation systems
- Programming fundamentals
- Energy conservation
- Waste management
- Apply the circular economy concept

5.4.2 Knowledge needed to achieve the competences

After the successful completion of this module, the learners will get the following knowledge:

PC systems

- PC Hardware characteristics
- Operative systems characteristics
- IT Virus typologies
- General classification about cyber attacks/dangers
- URL Composition

Networking

- Network components types and characteristics
- Network components installation
- Network components configuration
- Test of network components
- IPv4 and Ipv6 address structure
- Network masks determination
- Configuration of a Router as Default Gateways
- Different network types characteristics and connections
- Network components configuration
- Client/Server communication
- Types and structure of HTML tags

- IP address resolution in URL
- DNS functioning

Python & Database

- Variables and types of data
- Arrays of data
- Condition instructions
- Loop instructions Functions

Electronics

- Main electrical quantities
- Components of a electrical system
- Structure of a basic electrical circuit
- Types of electrical actuators
- Types of electrical sensors
- Connection of a electrical system

Sustainability

- Energy saving techniques
- Alternative energy resources
- Energy from Renewable Resources
- Avoid superfluous energy consumption
- Reduce waste
- Reusing items is another way to stop waste at the source
- Design for disposal or recycling
- Track waste
- Legislation
- Reduce consumption of raw materials
- Techniques to reduce consumption of raw materials
- Alternative resources
- Minimize waste
- Value of Energy and Resources
- Re use material
- Minimize waste from production
- Principles of Recycling
- Design products to be reused
- Minimize waste

5.4.3 Skills needed to achieve the competences

Moreover, the learners will get the following skills:

PC systems

- Choose and install the Operative System
 - Choose and install an Antivirus application
 - Check a system with an Antivirus
 - Choose and install a Browser Web
-
- Networking
 - Install and configure a network interface card
 - Install and configure a network switch
 - Install and configure a network router
 - Recognize Internet Protocol parameters
 - Configure Internet Protocol parameters
 - Categorize different network types
 - Configure the speed negotiation between NIC and Switch
 - Test the communication between network components
 - Class choose and device IP address setting
 - Communicate with ICMP Protocol
 - Recognize HTTP/HTTPS protocol characteristics
 - Recognize HTML characteristics

Python & Database

- Use and configure variables
- Use and configure arrays of data
- Use Condition and Loop instructions
- Configure and use functions

Electronics

- Measuring electrical quantities
- Connecting actuators and sensors in a electrical system
- Testing of a electrical circuit

Sustainability

- Environmental awareness skills
- Critical thinking
- Identify necessary energy resources for each task
- Ability to apply environmental friendly energy resources that effectively serve the purpose of the task
- Green skills
- Social responsibility

5.5 Timing and Credits

This training unit predicts 40 hours of learners work, roughly divided in:

- Asynchronous online courses: 30 hours
- Practical sessions: 10 hours

This introduction unit is not compulsory and its use is based on the needs of the learners.
For this it does not issue credits.

5.6 Insights for DTAM teachers

<https://www.tinkercad.com/>

Free platform to draw and test digital twins of electronic circuits, either stand alone or with Arduino boards

[Social Innovations for the Energy Transition](#)

Document where you can find in-depth information on the energy transition and related social innovation

<https://ourworldindata.org>

Site where you can learn more about world energy production and consumption through many graphs

<https://weee4future.eitrawmaterials.eu>

In-depth document on the subject of fundamental raw materials for technology

<https://climate.nasa.gov/>

Climate change represent one of the primary effects connected to human activities; on this site updated information on this topic

<https://www.footprintcalculator.org/>

Useful site to evaluate and to understand better the meaning of ecological footprint, one of the most valid parameters for quantifying sustainability.

<https://www.cleanenergycouncil.org>

On this site you can learn more about the technologies used to produce energy from renewable natural sources.

6 Training Module 2: Big Data

6.1 General description

This course is for technicians and professionals who would like to understand the core tools used to wrangle and analyze big data, as well as the core tools used for distributed processing of large data sets across clusters of computers. Although the tools that are presented are generally applicable for data processing, analysis and visualization, the module is mainly oriented for advanced manufacturing use cases. At the end of the module, you will learn how to use Python for data analysis and data visualization. Moreover, you will learn how to use the Hadoop and Pig frameworks for distributed processing of large data sets.

6.2 How to use the training module

The training material can be used as a reference for enhancing the skills and competencies of the DTAM learners in the domain of Big Data. It is up to you to decide how you will progress through the course depending on your prior knowledge on Big Data theory and technologies. In the case that you lack knowledge of Python (which is the programming language that is used through this course) then it is strongly recommended to go firstly through the module “TM1 - Information technology and operational technology”.

6.2.1 Learning units and assessment

This training module is structured in 3 learning units:

- Introduction to Big Data
- Introduction to Python for data analysis
- The Apache Hadoop framework

At the end of each unit learners have to complete the assessment test, where several quizzes will evaluate the reached results. The quizzes are generally multiple choice type, with one or more correct answers, but there are also other kinds of tests as sentences to complete with proposed words.

Each quiz is considered passed if **at least 80%** of the answers are correct

6.2.2 Exercises

Some exercises are proposed in the training module, their execution needs only the material available in the IoT lab. (ref. to the IoT lab section of the guide). The exercises are not compulsory but are warmly recommended to get a complete understanding of the proposed arguments. The evaluation of the exercises is in charge of the teacher.

The proposed exercises are located in the following sections:

- **Hadoop installation on Ubuntu VM.** At this exercise the students are asked to install Hadoop at a virtual machine running Ubuntu.
- **Interacting with Hadoop running at Docker containers:** At this exercise the students are asked to interact with Hadoop (e.g. HDFS and MapReduce) at a Hadoop installation running at Docker containers.
- **Apache Pig hands-on.** At this exercise the students are asked to practice with Apache Pig.

6.3 Learning platform units: index & schedules

This training module is available in the platform structured in the following units and sub-units

- Introduction to Big Data
 - Basic concepts of Big DataBook
- Python for Data Analysis
 - Introduction to Python for data analysisBook
 - The NumPy library in Python for the creation of large, multi-dimensional arrays and matricesBook
 - The Pandas library in Python for data analysisBook
 - The Matplotlib library in Python for data visualizationBook
- The Apache Hadoop framework
 - Basic concepts of Apache Hadoop
 - Activity: Hadoop fundamentals
 - The Hadoop Distributed File System
 - The Hadoop Yarn
 - The Hadoop MapReduce
 - Hadoop Administration

Hadoop MapReduce with Python

- Hadoop and Pig

6.4 Learning Outcomes

6.4.1 Competences

After this training module successful completion, the learners will be able to:

- Carrying out data collection and integrating data storage systems.
- Use data processing techniques for decision making.
- Work with data generated within the industrial environment, from its capture and storage to its exploitation through data processing methods.
- Exploit data to derive insights regarding the operation and maintenance of machines.
- Design the architecture of an infrastructure for the distributed processing of big data.
- Communicate engaging data visualizations to support decisions towards the improvement of the digitized processes in industrial environments.

6.4.2 Knowledge needed to achieve the competences

After the successful completion of this module, the learners will get the following knowledge:

- Big data main characteristics
- Big data at advanced manufacturing
- The data analysis process and different types of data
- How to use the Jupyter Notebook to write Python programs
- Main Python tools for exporting and importing data
- Reading, different types of files in Python
- Missing values and how to handle them with Python
- Processing different types of data with Python
- The NumPy package in Python for the creation of large, multi-dimensional arrays and matrices
- The Pandas library in Python for data analysis
- The Matplotlib library in Python for data visualization
- Main features and components of Hadoop framework
- The Hadoop Distributed File System
- The Hadoop Yarn
- The Hadoop MapReduce
- Basic administration of an Hadoop cluster
- How to develop MapReduce programs with Python
- Pig programming language

6.4.3 Skills needed to achieve the competences

Moreover, the learners will get the following skills:

- Preparing data for analysis using Python
- Importing and Exporting Data in Python
- Dealing with Missing Values in Python
- Performing data preprocessing using Python
- Performing simple and complex data analysis using Python
- Calculating basic statistics with Python
- Performing data visualizations using Python
- Using the Hadoop framework for data storage and processing
- Using the storage (HDFS) and processing (YARN) services of Hadoop
- Using the MapReduce framework
- Submitting and managing jobs in Hadoop
- Managing key Hadoop services
- Writing simple MapReduce programs
- Writing MapReduce program with Python
- Using Pig programming language to interact with Hadoop

6.5 Timing and Credits

After the training unit's successfully completion, the learners could get

- 1 ECVET credit for 25 hours of asynchronous online courses
- 1 ECVET credit for 25 hours of practical sessions

7 Training Module 3: Machine learning

7.1 General description

This course is for technicians and professionals who would like to understand the core tools used to implement machine learning techniques and analyze the shop floor data based on regression, classification, and clustering in order to train the systems for improved operations. The presented tools are the basic techniques and types of machine learning, the algorithms and the methods for it and their basic implementation in Python programming language. At the end of the module, one will learn the theoretics of machine learning, classification, regression, and clustering analysis. Moreover, the practical background with Python libraries and implementation will be covered by the modules.

7.2 How to use the training module

Machine learning is an exciting topic about designing machines that can learn from examples. The course covers the necessary theory, principles, and algorithms for machine learning. This training material may be utilized as a resource to support DTAM students improve their knowledge and abilities in the area of machine learning. The main aim of this module is to introduce students to the basic concepts and techniques of Machine Learning.

7.2.1 Learning units and assessment

This training module is structured in 5 learning units:

- Machine Learning - Introduction
- Supervised Learning
- Unsupervised Learning
- Regression with Python for ML
- Classification and Decision trees in Python

At the end of each unit learners have to complete the assessment test, where several quizzes will evaluate the reached results. The quizzes are generally multiple choice and "True or False" type questions.

Each quiz is considered passed if **at least 80%** of the answers are correct

7.2.2 Exercises

Some exercises are proposed in the training module, their execution needs only the materials available in the IoT lab. (ref. to the IoT lab section of the guide)

The exercises are not compulsory but warmly recommended to a complete understanding of the proposed arguments. The exercises evaluation is in charge of the teacher.

The proposed exercises are located in the following sections:

- Supervised Learning (Linear Regression): At this exercise the students are asked to implement a Linear Regression algorithm, in Python.
- Outlier Detection: At this exercise students are asked to apply outlier detection techniques.
- Decision Trees and RF classifier: At this exercise students are asked to implement one of the most famous machine learning models.

7.3 Learning platform units: index

This training module is available in the platform structured in the following units and sub-units

- Machine Learning Introduction
 - Definition
 - Machine Learning Categories
 - How it's made
 - Why insist on Machine Learning though?
 - Examples of machine learning use
 - Machine Learning advantages and disadvantages
 - Machine Learning for manufacturing applications
 - Global market examples
- Supervised Learning
 - What is supervised learning?
 - Mapping to real life Manufacturing Cases
 - Types of supervised learning
 - K Nearest Neighbor (kNN)
 - Advantages and disadvantages of Supervised Learning
- Unsupervised Learning
 - What is unsupervised learning?
 - Types of unsupervised learning
 - Unsupervised learning advantages
 - Unsupervised learning disadvantages
 - Classification vs clustering in machine learning

- Machine Learning - Regression with Python for ML
 - Linear Regression with Python
 - Multiple Linear Regression with scikit-learn
 - Polynomial Regression with Python
 - Advanced Linear Regression with statsmodel
 - Cost Function in the Linear Regression

- Classification and Decision trees in Python
 - Let's get started
 - Find the k nearest neighbors
 - Decision Trees in Python
 - Comparison of Decision Trees and KNN

7.4 Learning Outcomes

7.4.1 Competences

After this training module successful completion, the learners will be able to:

- Understand and analyze basic concepts of machine learning.
- Design and implement machine learning models using real-world data sets
- Understand how machine learning algorithms work and how they can be applied in industrial applications.
- Be able to understand and analyze data from diagrams.
- Report the results of analyzes and machine learning models in a constructive plot.

7.4.2 Knowledge needed to achieve the competences

After the successful completion of this module, the learners will get the following knowledge:

- Understand and analyze basic concepts of machine learning.
- Design and implement machine learning models using real-world data sets
- Understand how machine learning algorithms work and how they can be applied in industrial applications.
- Be able to understand and analyze data from diagrams.
- Report the results of analyzes and machine learning models in a constructive plot.

7.4.3 Skills needed to achieve the competences

Moreover, the learners will get the following skills:

- Preparing data for analysis using Python
- Test scripts in Python for Machine Learning
- Regression algorithms with Python
- Classification technique with Python
- Decision Tree implementation in Python
- Machine Learning techniques for improved digitized maintenance processes

7.5 Timing and Credits

After the training unit's successfully completion, the learners could get

- 1 ECVET credit for 25 hours of asynchronous online courses
- 1 ECVET credit for 25 hours of practical sessions

7.6 Insights for DTAM teachers

A useful glossary for all the machine learning term with informative examples:

<https://developers.google.com/machine-learning/glossary>

Python Tutorials:

<https://www.kaggle.com/learn/intro-to-machine-learning>

8 Training Module 4 – Internet of Things and sensors

8.1 General description

This course is for technicians and professionals who would like to understand the core hardware and tools used to generate data from an industrial environment and adjust parameters in the intelligent manufacturing environment. You will learn different technologies, architectures and protocols to make an IOT ecosystem possible. You will learn how to use a Raspberry and advanced sensors to improve the production process and make connected devices that can make the right choices based on data..

8.2 How to use the training module

The aim of this module is to enable learners to create sensor devices prototypes, program the devices (using Python) and have measurements sent to a central database. The module contains theory about different kinds of networks and both wired and wireless connections.

Learners will discover many different types of sensors and learn how to use some of them, using the provided exercises. Learners will be able to decide about when to use a Raspberry PI, Arduino or PLC.

8.2.1 Learning units and assessment

This training module is structured in 7 learning units:

- Introduction to advanced sensors
- Sensors
- Using a device to work with sensors
- Programming IoT with Python on a Raspberry PI
- Wired communication
- Wireless communication
- Data visualization platforms

Theory, hands-on exercises and self-assessment quiz questions will help the learners to determine their improvements. The module is concluded by a challenge, to be done in groups of learners.

The quizzes are generally multiple choice type, with one or more correct answers, but there are also other kinds of tests as sentences to complete with proposed words or matches between lists or images.

Each quiz is considered passed if **at least 80%** of the answers are correct

Each quiz is considered passed if **at least 80%** of the answers are correct

8.2.2 Exercises

Some exercises are proposed in the training module, their execution needs only the materials available in the IoT lab. (ref. to the IoT lab section of the guide)

The exercises are not compulsory but warmly recommended to a complete understanding of the proposed arguments. The exercise evaluation is in charge of the teacher.

The proposed exercises are located in the following sections:

- In the end of chapter 2 “sensors”, three exercises are provided
 - **Reading out RFID RC522 Tags (NFC);**
 - **Control a HD44780 LCD display via I2C;**
 - **Using a distance sensor (ultrasonic sensor HC-SR04)**
- In the end of chapter 4 “programming IOT with Python on a Raspberry PI” one exercise is provided:
 - **Operate a traffic light from python code**
- In the end of chapter 7 “Data visualizing platforms” one exercise is provided:
 - **Connection of Siemens PLC to Raspberry PI & NodeRed**

8.3 Learning platform units: index

This training module is available in the platform structured in the following units and sub-units. The estimated amount of hours is listed after each section, like (

- **1 Introduction to Advanced Sensors - (12 hours)**
 - 1.1 Introduction
 - 1.2 What is a sensor
 - 1.2.1 Application of sensors in manufacturing
 - 1.3 IoT networking
 - 1.4 System- and application software
 - 1.5 Connections to the web
 - 1.6 Data storage
 - 1.7 Linux
 - 1.8 Quiz
- **2 Sensors (12 + 4 hours)**
 - 2.1 Overview
 - 2.2 Temperature / Humidity / Air pressure / Gas sensors
 - 2.3 Motion sensors
 - 2.4 Navigation modules
 - 2.5 Raspberry Pi Sensors – Wireless / Infrared (IR) / Bluetooth
 - 2.6 Motors
 - 2.7 Analogous Raspberry Pi Sensors
 - 2.8 Power/Current Supply
 - 2.9 Displays
 - 2.10 Other Modules, Components and Raspberry Pi Sensors
 - 2.11 Quiz
 - 2.12 Exercise 1: Reading Out RFID RC522 Tags (NFC)

- 2.13 Exercise 2: Control a HD44780 LCD display via I2C
- 2.14 Exercise 3: Using a distance sensor (ultrasonic sensor HC-SR04)

- **3 Using a device to work with sensors (4 hours)**
 - 3.1 Which device is suitable for prototyping?
 - 3.2 Arduino Uno R3
 - 3.3 Raspberry PI 4 and Raspberry 3B+
 - 3.4 Quiz

- **4 Programming IOT with Python on a Raspberry PI (48 + 12 hours)**
 - 4.1 Using Python as IOT Programming language
 - 4.2 Arguments for using Python for IOT
 - 4.3 Book: "The Coder's Apprentice" by Pieter Spronck
 - 4.4 Project: physical computing by RaspberryPI foundation
 - 4.4.1 Python code for switching an LED on and off
 - 4.4.2 Python code for flashing an LED
 - 4.4.3 Python code for using buttons to get input
 - 4.4.4 Python code for Making a light-switch
 - 4.4.5 Python code for Using a buzzer
 - 4.4.6 Python code for Using a light-dependent resistor
 - 4.4.7 Creating a light-sensing circuit
 - 4.4.8 Python code for Using a movement (PIR) sensor
 - 4.4.9 Python code for Using an ultrasonic distance sensor
 - 4.4.10 Python code for Analogue inputs
 - 4.4.11 Python code for Using motors
 - 4.5 Exercise: operate a "traffic light" from python code
 - 4.6 Exercise: operate a "traffic light" from python code (answer)

- **5 Wired communication (4 hours)**
 - 5.1 KNX
 - 5.2 PLC

- **6 Wireless communication (4 hours)**
 - 6.1 WIFI
 - 6.2 LoRa
 - 6.3 Bluetooth
 - 6.4 4G/5G Cellular networks
 - 6.5 433MHz
 - 6.6 Z-wave
 - 6.7 Zigbee
 - 6.8 Quiz

- **7 Data visualizing platforms (4 hours + 4 hours)**
 - 7.1 Data visualization with Grafana

- 7.2 Open platform for interacting sensors (Home Assistant)
- 7.3 Processing data with NodeRed
- 7.4 Exercise: Connection of Siemens PLC to Raspberry PI & NodeRed

8.4 Learning Outcomes

8.4.1 Competences

After this training module successful completion, the learners will be able to:

- Characterize existing production processes by defining and measuring appropriate key performance indicators (KPIs).
- Reprogram and/or adjust manufacturing parameters in the intelligent manufacturing environment.
- Apply industrial communication solutions, carrying out data collection and integrating data storage systems.
- Integrate the production control system with the company's digital management systems.
- Identify the different technologies, architectures and protocols that make an IOT ecosystem possible.
- Design and deploy communications networks for IoT devices, selecting the most appropriate technology.
- Do a preliminary assessment of IT/OT network.
- Adapt the processes and/or machines by incorporating the selected digital technologies taking into account safety, efficiency and sustainability criteria.
- Reprogram and adjust operating parameters and re-adjust the system to new operating and monitoring requirements in the maintenance process environment.

8.4.2 Knowledge needed to achieve the competences

After the successful completion of this module, the learners will get the following knowledge:

- Basic knowledge of wide variety of sensors
- Basic knowledge of production processes
- Advanced knowledge of the applied sensors, what is the input/output
- Knowledge in programming languages used to collect data from sensors and adjust parameters of the process
- Knowledge of ETL processes
- Data types / Data conversion
- Previous programming skills
- Basic knowledge of DMS
- Knowledge of collecting serial data
- I2C bus
- PoE
- Zigbee
- Analog/Digital data pins

- SPI
- Voltage systems
- Advanced Ohms law
- NB-IoT communications
- WiFi communications
- LoRa communications
- Bluetooth communications
- 4/5G communications
- ZigBee and other local protocols etc.
- Knowledge of firewalls, proxys, network ports, protocols
- "Knowledge of safety regulations identified per country
- Sustainability
- Certification of IEEE, ISO, NEN and CE
- Knowledge of update intervals (For example Python builds)
- Knowledge of vulnerabilities, what can go wrong"

8.4.3 Skills needed to achieve the competences

Moreover, the learners will get the following skills:

- Define KPIs by using KPI Karta
- Write scripts to collect data from sensors
- Programming in Python
- Write scripts in Python to copy data from Raspberry Pi to data storage using HTTP(s)
- Collect and sending data using Python
- Apply the concepts in advanced sensorica device like a Raspberry Pi
- Write scripts to send data using the most appropriate network
- Reprogram and/or adjust manufacturing parameters in the intelligent manufacturing environment. Apply industrial communication solutions, carrying out data collection and integrating data storage systems."
- Build a simple setup to verify if the data collected is transferable
- Interpreting of regulations during the advanced sensorica module
- Check for updates
- Check for vulnerabilities

8.5 Timing and Credits

This training unit predicts 140 hours of learners work, roughly divided in:

- Asynchronous online courses: 88 hours
- Practical sessions: 20 hours
- Challenge group-assignment: 40 hours

This introduction unit is not compulsory and its use is based on the needs of the learners. For this it does not issue credits.

After the training unit's successfully completion, the learners could get

- 1 ECVET credit for 25 hours of asynchronous online courses
- 1 ECVET credit for 25 hours of practical sessions

8.6 Reference to IoTLab Challenges

This module is concluded by a group challenge, where the students will apply the learning outcomes to create a greenhouse for letting plants grow, measuring the amount of light and moisture and use a pump to apply water.

The challenge is to be evaluated by a teacher, using provided rubrics.

8.7 Suggested Hardware and Software

For every student:

- Raspberry PI + power adapter + network cable
- Keyboard and mouse and monitor (only necessary for setting up the raspberry, from then on VNC can be used to remotely use the Pi from a laptop)
- Breadboard
- GPIO extension board to connect Raspberry PI to breadboard
- For making the exercises in chapter 2:
 - RC522 kit (for working with RFID / NFC)
 - HD44780 LCD display
 - HC-SR04 ultrasonic distance sensor
- For making the exercises in chapter 4:
 - Solderless breadboard
 - 20 Male-to-female jumper leads
 - 20 Male-to-male jumper leads
 - 1 Tactile button
 - 3 LED's
 - HC-SR04 ultrasonic distance sensor
 - Passive infrared motion sensor
 - Light Dependent Resistor
 - 5V motor
 - 3x 330 ohm resistor
 - 470 ohm resistor
 - 1 x 1uF capacitor
 - Buzzer
 - Motor controller
 - 1 MCP3008 ADC
 - Potentiometer
- For making the exercise in chapter 7:
 - Siemens PLC Simatic S7-1200 or S7-1500. Most of the 1200 family PLCs have analog inputs available on the main board, if they are not present is needed also a Analog Input card.
 - Ethernet Cable to connect PLC and Raspberry PI
 - One or more analog sensor. It doesn't matter the kind of sensor, in the PLC the signal is always managed in the same way.
 - Siemens Tia Portal programming System

8.8 Insights for DTAM teachers

<https://www.tinkercad.com>

Free platform to draw and test digital twins of electronic circuits, either stand alone or with Arduino boards

<https://nodered.org>

Free tool to automate signals/messages and visualize workflows

9 Training Module 5 – Cybersecurity

9.1 General description

This course is for technicians and professionals who would like to define and implement security strategies in industrial organizations and infrastructures. At the end of the module you will learn how to perform cybersecurity diagnostics, identifying vulnerabilities and implementing the necessary measures to mitigate them by applying the current regulations and industry standards, following the protocols of quality, occupational risk prevention and environmental respect.

9.2 How to use the training module

The aim of this training module is to complete or refresh the learners cybersecurity competences in order to start in the best way their works on DTAM Project.

The Digital Evaluation Tool gives to the learners an indication about their starting level and a suggestion of which are the compulsory learning unit to complete before to start to work on DTAM.

9.2.1 Learning units and assessment

This training module is structured in 6 learning units:

- 1: IT/OT environment integration

In this Learning Unit the student will learn which are the main characteristics of the Information Technologies (IT) and Operational Technologies (OT), so they can understand their differences and the difficulties related to connecting them.

- 2: Risk Scenarios

In this Learning Unit the student will learn what are the major cybersecurity dangers in the field of industrial networks and equipment, what are the most common cyber-attacks and how to identify known vulnerabilities of industrial systems.

- 3: Cybersecurity policies

In this Learning Unit the student will learn which are the most important security policies used to secure data, equipment and industrial facilities.

- 4: Securing industrial networks

In this Learning Unit the student will learn which are the most important techniques used to secure the assets of an industrial manufacturing company (databases, communication systems, computers, PLC's, network equipment, connected machines...) taking into account the need to connect all these assets in a network.

- 5: Anomaly Detection

In this Learning Unit the student will learn the most important concepts and techniques related to network monitoring for the prevention and detection of anomalies caused by unauthorized access to the company network.

- 6: Cybersecurity diagnosis and reports

In this Learning Unit the student will learn which are the most important steps and particularities of a cybersecurity diagnosis in an industrial network, as well as the most relevant aspects of a cybersecurity report.

At the end of each unit learners have to complete the assessment test, where several quiz will evaluate the reached results. The quizzes are generally multiple choice type, with one or more correct answer, but there are also other kind of test as sentences to complete with proposed words or matches between lists or images.

Each quiz is considered passed if **at least 80%** of the answers are correct

9.2.2 Exercises

Some exercises are proposed in the training module, their execution needs only the materials available in the IoT lab. (ref. to the IoT lab section of the guide)

The exercises are not compulsory but warmly recommended to a complete understanding of the proposed arguments. The exercises evaluation is in charge to the teacher.

The proposed exercised are located in the following sections:

- VPN creation: a VPN will be created between a client and a server using OpenVPN. Once connected the client will access another computer(another VM running a web server).
- Network monitoring: network traffic will be monitored using open source software (Wireshark) to read data from a SSH or Telnet connection to any equipment (a virtual machine, PC, PLC or Raspberry). The read data will be encrypted (SSH) or plain text (Telnet) depending on the connection type.
- Modbus attack: a simulated Modbus industrial network will be attacked using open source tools (Kali Linux), we will find the attacked target (a Modbus client) and change its configuration data, which in a real situation could cause a system failure.
- Digital certificates: a SSL/TLS certificate will be created and installed in a web server. Then data traffic between the server and a browser client will be analyzed.

9.3 Learning platform units: index

This training module is available in the platform structured in the following units and sub-units

- IT/OT environment integration
 - IT/OT environment features
 - Cybersecurity for IT/OT integration
- Risk scenarios
 - Types of Industrial Control Systems
 - Physical and logical network architecture
 - Hazard and types of hazards
 - External cyberattacks
 - Common vulnerabilities and Exposures (CVE)
- Cybersecurity policies
 - Industry standards and regulations
 - Cybersecurity policies
 - Identity and access control management
 - Management of system updates
 - Management of back-up copies
 - Management of information storage in corporate network
 - Management of information storage in workstations
 - Management of cloud storage
 - Management of information storage removable devices
 - Management of logs
 - Management of mobile devices
 - Management of information
 - Management virus and malware
 - Management of relations with suppliers
 - Management of wifi and external networks
 - Management of passwords
- Securing industrial networks
 - Zoning and segmentation
 - Secure communications in industrial networks
 - Data Security
 - Access control systems and credentials
 - Secure coding
- Anomaly Detection
 - Anomaly monitoring and detection systems
 - IDS/IPS and SIEM tools

- Cybersecurity diagnosis and reports
 - Diagnosis and reports

9.4 Learning Outcomes

9.4.1 Competences

After this training module successful completion, the learners will be able to:

- Integrate the production control system with the company's digital management systems.
- Determine organizations' cybersecurity risk profiles by identifying good practices, standards and applicable regulations.
- Identify the different technologies, architectures and protocols that make an IIOT ecosystem possible.
- Establish the configuration of industrial control systems minimizing the risks of the organization.
- Apply industrial communication solutions, carrying out data collection and integrating data storage systems.

9.4.2 Knowledge needed to achieve the competences

After the successful completion of this module, the learners will get the following knowledge:

- Understanding of the changes needed for the IT /OT convergence
- Basic understanding of industrial control systems (ICS)
- -Industrial communication networks and protocols
- Types of cybersecurity hazards
- Types of credentials and access control systems (Digital signatures...)
- Main concepts of zoning and segmentation in ICS
- Know what is the vulnerability management system (CVE...)
- Main industry standards and applicable regulations related to cybersecurity
- Main features of cybersecurity policies and measures
- Network control and supervision devices for secure communications in ICS (IDS, IPS...)
- Basic principles of data security
- Basic principles of access controls
- Basic principles of secure coding
- Relevant information for cybersecurity reports

9.4.3 Skills needed to achieve the competences

Moreover, the learners will get the following skills:

- Analyze IT and OT environments
- Implement IT/OT network coupling
- Segment an industrial network
- Search for information on known vulnerabilities in industrial control systems.
- Identify Vulnerabilities
- Identify people, devices and systems
- Identify the cybersecurity main policies in an organization
- Analyze the features of the communication protocols
- Propose solutions for secure remote access
- Propose solutions for data security
- Propose solutions for secure industrial communications
- Apply Intrusion detection systems (IDS)
- Apply standards for secure communications

9.5 Timing and Credits

After the training unit's successfully completion, the learners could get

- 1 ECVET credit for 25 hours of asynchronous online courses
- 1 ECVET credit for 25 hours of practical sessions

9.6 Reference to IoTLab Challenges

During the IoTLab cybersecurity challenge students will be able to practice some of the most important cybersecurity skills, as they are:

- VPN's creation and configuration
- Use of SSL/TLS certificates
- Motorize network traffic
- Check password strength
- Cypher communications between different devices
- Create security policies for back-ups, passwords...
- Install and configure a firewall
- Install and configure security systems such as video surveillance, alarms...

Before the challenge execution students will practice some of these skills doing the proposed exercises in the training module. Other skills will be acquired reading the teacher proposed websites.

9.7 Suggested Hardware and Software

The software used during the practical exercises and challenge will be:

- **Virtualbox** (or similar) to create the needed virtual machines.
- **OpenVPN** client and server
- **Wireshark** sniffer
- **Putty** remote connection client (SSH, Telnet...)
- **Apache** web server
- Digital certificates created by **openssl** application
- Open firewall application **PFSense**

The hardware used during the practical exercises and challenge will be:

- PC with internet and LAN connection
- A Ethernet LAN switch
- Arduino with PIR sensor and Ethernet adapter
- CCTV IP cameras (basic ones)
- Raspberry PI for firewall simulation with PFSense
- USB to Ethernet NIC adapter for the Raspberry PI second Ethernet port to simulate the firewall with PFSense

9.8 Insights for DTAM teachers

<https://www.wireshark.org>

Website to download the free sniffer Wireshark, there is an online manual to learn how to use it and a FAQ section.

<https://openvpn.net/>

Website of OpenVPN project, a free VPN client-server software.

<https://www.ipfire.org/>

Website to download the free sniffer firewall IPFire, it is easy to install and configure. There is an online community in which questions are asked and answered.

<https://password.kaspersky.com/>

Website to check if a password is strong enough.

<https://deliciousbrains.com/ssl-certificate-authority-for-local-https-development/>

Website to learn how to create a local SSL/TLS Certification Authority.

<https://zoneminder.com/>

Website of Zoneminder project, which could be used to install and configure a simple CCTV video surveillance system.

10 Training Module 6 – Transversal Competences

10.1 General description

This course is for technicians and professionals who would like to access and improve the learning process in a different and pioneering way. At the end of the module, on a personal level you will have the ability to achieve individual learning, adapt to different situations, find innovative ideas and surpass difficulties. It is well known that a strong and complete personality is the first step on professional success. Furthermore, on a social level you will be able to communicate with other people and cooperate properly. Last but not least, you will enrich your knowledge with the ability to handle effectively big information volume.[S1]

10.2 How to use the training module

The aim of this training module is to complete or refresh the learners competences in order to start in the best way their works on DTAM Project.

Soft skills have proved to be of great significance for our well-being, our professional life and personal path. By sharpening your soft skills through the training material and the exercises designed specifically for this module, we create a strong basis, on which you can build the rest of your training.

The Digital Evaluation Tool gives to the learners an indication about their starting level and a suggestion of which are the compulsory learning unit to complete before to start to work on DTAM.[S1]

10.2.1 Learning units and assessment

This training module is structured in 8 learning units:

- 1. Self-learning
- 2. Flexibility
- 3. Problem solving
- 4. Communication
- 5. Leadership
- 6. Globalization
- 7. Information analysis
- 8. Project Management

At the end of this module learners have to complete the assessment test, where a quiz will evaluate the reached results. The quiz of this unit is of multiple choice type, with one correct answer

Each quiz is considered passed if **at least 80%** of the answers are correct

10.2.2 Exercises

Some exercises are proposed in the training module, their execution needs only the materials available in the IoT lab. (ref. to the IoT lab section of the guide)

The exercises are not compulsory but warmly recommended to a complete understanding of the proposed arguments. The exercise evaluation is in charge of the teacher.

The proposed exercises for this module are located in the following sections:

Self-learning

During the lifetime of the course, each participant will try to recreate different versions of an existing object of their choice, with 3D modeling. At the end of the training, all the participants will present their versions of the object, but also their journal of their self-learning/researching experiences. It is important to describe their thoughts and ideas, their feelings and how they navigated from subject to subject, in order to come up with their finalized product.

Flexibility and critical thinking

"Is human law above ethics? Or the way round?"

Divide into two groups supporting opposite opinions and come up with at least 5-10 arguments to support your opinion. You can then switch the argument you support and come up with more arguments that have not been mentioned before.

Problem solving

One of your partners in a very important project is constantly causing delays to the schedule which annoys all the stakeholders. You know that this person, though, faces health issues that have not been revealed to anyone but you, which sometimes get in the way of their professional performance and punctuality to deadlines.

How do you deal with the issue? What ways can you come up with to solve the issue of them being late to deadlines, but also how can you calm the rest of the partners, without exposing personal data and information?

Communication and cooperation

All the participants form a circle, and start walking, trying to keep the same rhythm and leave no gaps between them. The circle should always look like a circle, which means that everyone must be aware not to be left behind, or rush, so the shape of the circle looks as perfect as possible. With the instruction of the trainer, one participant, not named or instructed specifically, should change the rhythm of their walking, turn it to running, or even jumping, walking slower or even creating a weird or funny walk. The rest of the group should follow as quickly as possible, which means that they are all aware of their surroundings and the choices of others. Anyone can change the rhythm, or way of walking, but the circle should always be a circle, and everyone needs to be aware of that.

Leadership

In five to ten minutes prepare a speech about leadership, stating your ideas and vision on what leadership is. Every participant will read their speech to their fellow peers, and then everyone will vote which speech and person they found most inspirational and suitable for a leader. Discussion could follow as to what led them to vote someone and not someone else, followed by personal reflection.

Globalization-Intercultural communication

Search online and find at least 5 interesting facts -which are valid and not just stereotypical about a country of your choice, and then create a small quiz to share to your peers. Use a multiple-choice format, with one correct and two wrong answers. Sharing all your quizzes you will end up with new knowledge acquired but also you will have practiced self-learning and collecting information too. After the completion of the quiz, present a small plan on how you would interact in a professional setting to show your appreciation for the culture.

Information and data analysis

Every person of the group is called to find online information and data about the pandemic of Covid-19 and compare it to previous global pandemics. You only have 15 minutes to go online and collect information, which you then must present to your peers. Also include invalid information and ask your peers if they found out which is fake. Ask them how they checked the validity of the information. Conversation can follow about the way we collect information, how we go from one source of information to another and how we check the validity.

Project Management

Your company will launch a new electric vehicle that you know could be controversial and cause reactions from your competitors. In 15' create your own project management plan, from the conception of the product to its launching, taking under consideration any risk factors and how you could avoid them. If you are a large group, divide in smaller groups of three and work on specific steps of the management process that you will assign in between you.

10.3 Learning platform units: index

This training module is available in the platform structured in the following units and sub-units

- **Self-learning**
 - Definition
 - Benefits of self-learning
 - Seven steps for an effective self-learning process
 - The six C's of self-learning
 - Self-learning after the pandemic

- Self-learning as a tool to boost creativity
- Self-learning as a tool for upskilling and new opportunities
- Self-learning for developing other transversal skills
- Exercise 1: Self-Learning
- Quiz 1: Self-Learning

- **Flexibility and Critical Thinking**
 - Flexibility and Adaptability
 - Definition of the term
 - Flexibility and adaptability to new situations
 - Characteristics of adaptable and flexible person
 - Ways to make successful changes
 - Tips for increasing the effectiveness of changes
 - Critical and Innovative thinking
 - Definition of critical thinking
 - Process of critical thinking
 - The components of critical thinking
 - Critical thinking abilities
 - The meaning of innovative thinking
 - Ten ways to develop innovative ideas
 - References
 - Exercise 2: Flexibility and Critical Thinking
 - Quiz 2: Flexibility and Critical Thinking

- **Problem Solving**
 - Problem solving definition
 - Why are problem solving skills essential today
 - Problem solving skills
 - Problem solving as a mental process
 - Nine steps of an effective problem-solving process
 - Creativity techniques
 - SCAMPER
 - References
 - Exercise 3 : Problem solving
 - Quiz 3 : Problem solving

- **Communication and collaboration**
 - Communication
 - Definition of term
 - Methods of communication
 - Why are communication skills so important today
 - Main set of principles to achieve effectiveness in communication
 - Cooperation-Team working
 - Definition of Cooperation
 - Which are the benefits of an effective collaboration, especially after the stress caused by the COVID-19 pandemic
 - Strategies to create a well-balanced and efficient team
 - References

- Exercise 4: Communication and collaboration
- Quiz 4 : Communication and collaboration
- **Leadership**
 - Definition of leadership
 - The complexity of leadership
 - The characteristics of a successful leader
 - Effective ways to lead your team
 - References
 - Exercise 5: Leadership
 - Quiz 5: Leadership
- **Globalization and Intercultural Communication**
 - Basic forms and elements of intercultural communication
 - Different cultures and ways of thinking
 - Obstacles to an effective intercultural communication
 - How to improve your intercultural skills
 - Value of acceptance
 - References
 - Exercise 6 : Globalization and Intercultural Communication
 - Quiz 6: Globalization and Intercultural Communication
- **Information and data analysis**
 - Information analysis
 - Data analysis key concepts
 - Data analytics in 5 steps
 - Data, information and systems
 - Data vs Information vs Analytics
 - Types of Data Analytics
 - Control reliability of information
 - Exercise 7: Information and data analysis
 - Quiz 7: Information and data analysis
- **Project Management**
 - Project Management
 - Project and Project Management definitions
 - Project Lifecycle
 - Project Planning and Implementation
 - Risk analysis
 - Planning tools
 - The importance of communication
 - Change of management
 - Necessary steps for a successful change management process
 - References
 - Exercise 8: Project Management
 - Quiz 8 : Project Management

10.4 Learning Outcomes

10.4.1 Competences

After this training module successful completion, the learners will be able to:

- Have the ability to diagnose their needs and learn themselves, by taking the initiative.
- Be flexible and adaptable to handle new situations.
- Learn the right way to solve their problems.
- Find solutions to difficult or complex issues by breaking down information into smaller categories.
- Obtain a more critical and at the same time innovative way of thinking.
- Be able to communicate on a fundamental and effective level.
- Cooperate and work in teams, achieve an effective collaboration.
- Efficiently deal with the stress and strains of the modern workplace.
- Be able to lead teams successfully.
- Attain an intercultural understanding and an interest about internalization.
- Collect, process and analyze information.
- Plan and create projects by creating content.

10.4.2 Knowledge needed to achieve the competences

After the successful completion of this module, the learners will get the following knowledge:

- Learn by doing/ capitalizing new knowledge- new opportunities to learn/ Critically assess the resources/ learn how to learn/ individual learning
- Basic knowledge on project management/New tools- technologies/ Strategy development/Adaptive thinking/ receptive to new ideas, solutions, considerations
- Problem solving techniques/Creativity techniques/Analytical Tools for solving problems/ Complex thinking
- Ability to understand and count the value of information/social intelligence/ knowing your knowledge/ self-abasement
- Communication techniques/ Active listening/ Reflective Listening/ Picking the right medium/ Non-verbal communication/ Give and receive feedback appropriately/ Clarity and Concision/ Emotional Intelligence
- Group Dynamics/ Communication techniques/ Communication Technology/ Conflict resolution techniques/ Methods of Team Working/ Stress Management
- Self-motivation/ goals achieving, exchange and propose ideas/ take decisions/ utilize proposals/ leading teams
- Respect for diversity/ intercultural understanding/intercultural ideas/ worldwide identity

- Analyze available information/ Compare, Verify and Interpret Information/ Categorize Information/ turn data into insightful interpretations
- Prioritize, organize and manage, principles of project management

10.4.3 Skills needed to achieve the competences

Moreover, the learners will get the following skills:

- Creative thinking skills/ Learning by experience skills/ Cognitive skills/ knowledge management skills/ Research skills/ Lifelong Learning
- Critically analyze the situation/ Change strategies and mindset in order to adapt to new situations/ critically analyze former strategies and their application to new situations/ Create new strategies/ Innovation Thinking
- Identification and definition of the problem
- Research skills
- Analytical skills
- Break down the issue to its critical components
- Create alternative solutions
- Evaluate alternative solutions
- Risk assessment skills
- Evaluation and Identification of the best solution to the problem
- Evaluate and identify alternative solutions that can be applied if the chosen one does not work
- Observation/ analysis/interpretation/evaluation/ inference/ creativity skills
- Communication Skills/ Social Skills/ Listening communication/ presentation skills/ verbal communication skills/written communication skills/ Empathy/ Open Mindedness
- Collaboration skills/ Team Management Skills/ Networking skills/ Stress Management Skills/ Negotiation Skills/ Conflict Resolution Skills
- Advising/ coaching/ conflict resolution/ decision making/ diplomacy/ team spirit/ cooperation
- Acceptability/ globalization/ broad reach of interests
- Analytical Skills/ Identification of critical components of an issue/ Critical Thinking towards information
- Planning and Organizing Skills/ Goal setting and Management skills

10.5 Timing and Credits

After the training unit's successfully completion, the learners could get

- 1 ECVET credit for 25 hours of asynchronous online courses
- 1 ECVET credit for 25 hours of practical sessions

11 IoTLab

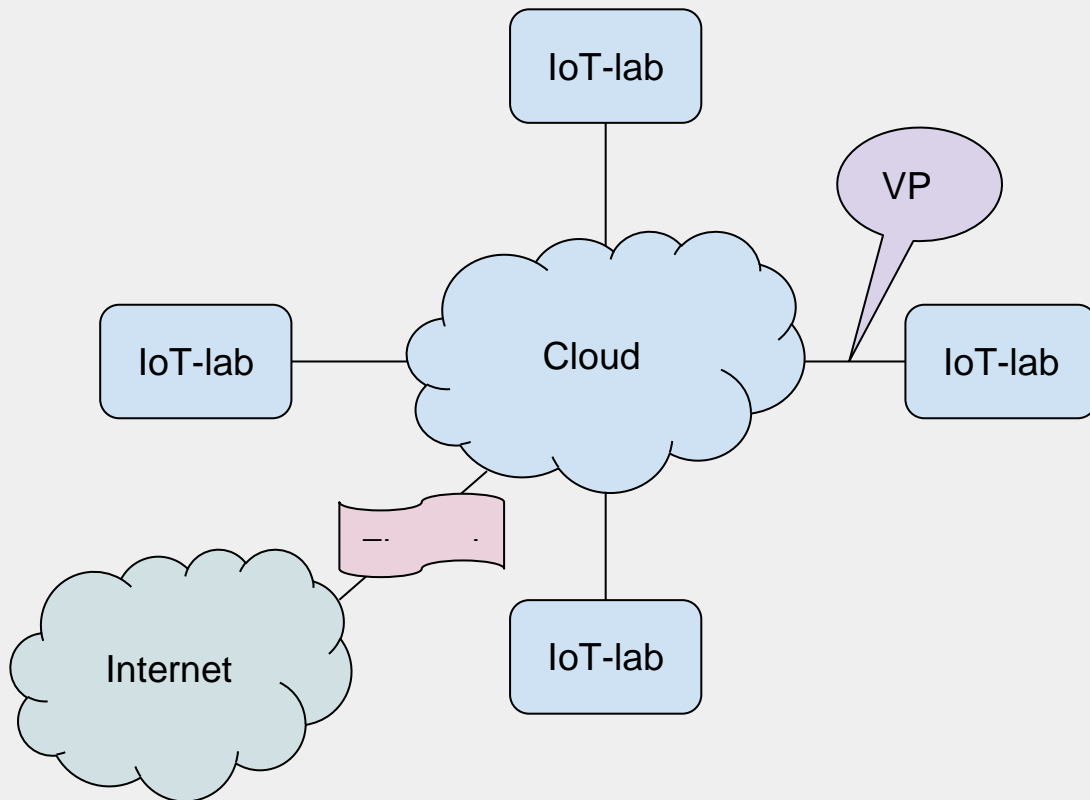
As mentioned in the introduction, the project document [“Features of the DTAM IoT Lab”](#) describes the general structure of the lab, as well as a list of supported hardware and components.

It will start by describing the minimum setup required, while highlighting potential upgrades which would enable additional functionality. While the IoT-lab is designed to be the facility where the assignments can be performed, a lab is first and foremost an environment where one can experiment and learn. This means that also the lab itself is subject to change and development. It is therefore the hope and aim of the writer that the IoT-lab eventually becomes much more than just the basic setup described in this document.

These are the requirements for the IoT-lab

- All assignments from the different training modules of the DTAM curriculum can be performed in the IoT-lab
- The IoT-lab will be designed to accommodate a minimum of 10 students simultaneously, provided they work in teams of 2. This means that a minimum of 5 experimental setups need to be available.
- The IoT-labs will be connected to a central cloud, allowing for the exchange of data.
- Data will also be stored locally in each IoT-lab
- Necessary services will run locally in each IoT-lab to guarantee local availability in case of network or cloud problems.

The basic interconnection of the IoT-labs will be through a central cloud. The connections to the cloud will be over VPN, thereby securing all exchanged data and virtually joining all labs in one network. For security purposes, all network traffic will be routed through the VPN connections, even internet traffic. This means that the whole network of IoT-labs is only connected to the internet at one point, making it more secure and only dependent on the configuration of one firewall.



Cloud services

- VPN server
- Non-relational database (MongoDB, InfluxDB)
- Grafana server
- MQTT server
- Hadoop framework
 - define number of cores, RAM etc

11.1 Hardware description

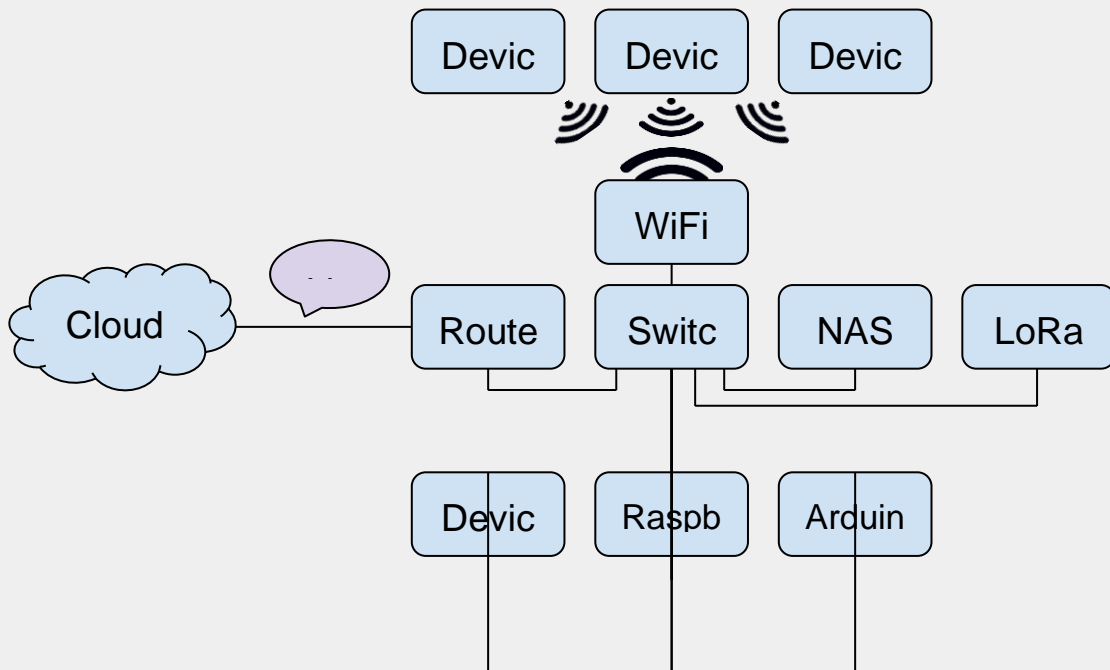


Figure schematically shows the hardware setup for the IoT-lab.

You will need a local IT network administrator with permission to assign your lab with a public ip, and to make port forwardings (UDP 4500 & UDP 500) to your router, and to configure an internal IP for your router.

■ 11.1.1 Router

With respect to the router, a couple of requirements are important

- stability and reliability
- ability to connect to a vpn server
- integrated wifi access point (optional alternative for separate access point)
- integrated LTE/4g link for WAN fallback option (optional)

integrated LAN ports (optional alternative for separate switch in case only limited amount of ports are needed)

Because of the availability of and experience with Cisco routers at Da Vinci College, it was decided to work with a Cisco 2821 router. Even though the specific type of router is end-

of-life, it is still very reliable industrial grade hardware and provides a stable infrastructure for the IoT-labs. This solution does not however have the LTE/4g backup option, so if that is desired, it will need to be created separately.

■ 11.1.2 Switch

Depending on the need for wired ethernet connections in the lab, it may be necessary to add a switch to the infrastructure. If so, it is highly recommended to choose a switch with PoE(+) support. This will allow for devices to be powered over ethernet, not only devices such as access points (see next section), but also IoT devices such as IP cameras and Raspberry Pi's. For the basic IoT-lab setup it is not necessary to have a managed switch, but it may be an interesting option and make the lab more future proof.

■ 11.1.3 Wifi access point

Also because of availability and professional status, the NetGear WNDAP360 was selected as the wireless access point to be used. It can be powered over ethernet, which works well in conjunction with the Cisco Catalyst 2960S.

■ 11.1.4 NAS

The NAS in the network will provide local storage of the data, while simultaneously running the essential services for the IoT-lab.



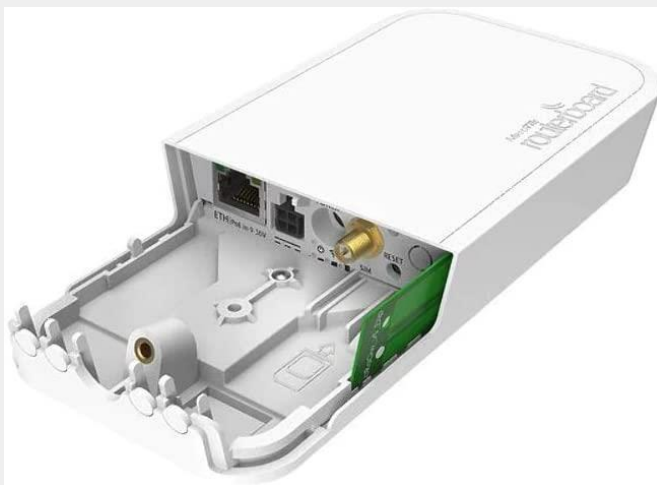
A reliable and powerful NAS is the e. It has 4 bays and is extendable to 9 bays with the DX517 expansion unit if needed. It is an entry model professional NAS intended for small businesses. Obviously there are more heavy duty NAS systems on the market, which may be interesting for the IoT-lab, but they also come with a price. Within the current scope of the IoT-lab, the

Synology DS920+ should be sufficient to provide all necessary services.

The minimum recommended configuration for the NAS is two 4TB drives in mirroring setup, ideally using SHR (Synology Hybrid RAID) and one 4TB drive as hot spare. Also it is highly recommended to install a memory module of 16GB to bring its total memory capacity to 20GB. This will make running services on the NAS much smoother.

■ 11.1.5 LoRa gateway

There are many communication technologies available for IoT applications, such as NB-IoT, Sigfox and LoRa. Specifically LoRa (Long Range) is an interesting technology for students because it is easily accessible without the need for investing in industrial grade hardware, while at the same time students do learn the intricacies of these types of technologies. It was therefore decided to integrate LoRa into the IoT-lab infrastructure. On a hardware level this simply means connecting a LoRa gateway to the network.



There are many suitable LoRa gateways. One such gateway for indoor use is the MikroTik wAP LoRa8 kit. Unfortunately this device is not currently (june 22) available in all countries.

An excellent outdoor (and semi-professional) Lora Gateway is the Wisgate Edge Max RAK7249. It is waterproof and uses industrial grade hardware. Together with the 8dbi 1300 mm long antenna, this gateway has an excellent range and can be mounted outdoors. Moreover it has an integrated LoRaWAN server, which means that the gateway could be operated standalone, without the need for a cloud LoRaWAN server.



■ 11.1.7 Devices

The IoT-lab will contain a variety of devices that will generate data through connected sensors or act as actuators or both.. All IoT-labs will have the same basic setup of devices. Which additional (advanced) devices will be connected depends on the availability of the hardware in each IoT-lab.

One of the challenges in creating the IoT-lab is to balance expenses with respect to the necessary hardware. On one hand it is preferable to create a training situation for the students that mimics industry conditions as best as possible. On the other hand it is not financially feasible to have industrial hardware available in great quantities. Therefore the general approach will be to teach the important principles of the training modules using reliable hardware that is not necessarily industrial grade, thereby making it more affordable.

- **Permanent**

These devices are always connected and turned on and provide permanent data collection. They are not used for experimentation, they provide a constant data stream to the database.

- **Workstations**

These devices are used by the students to perform their assignments and for experimentation. They will not always be active or functional, nor do they have to be.

- **Remote access stations (accessible by other labs)**

Specific devices that can be used for remote access by other IoT-labs

- **Industrial hardware**

To make most use of already existing industrial grade hardware at each site the aim is to connect existing hardware to the IoT-lab where possible. This will give students the opportunity to also learn with hardware that is representative for what they will encounter in production environments.

■ 11.1.8 Raspberry Pi

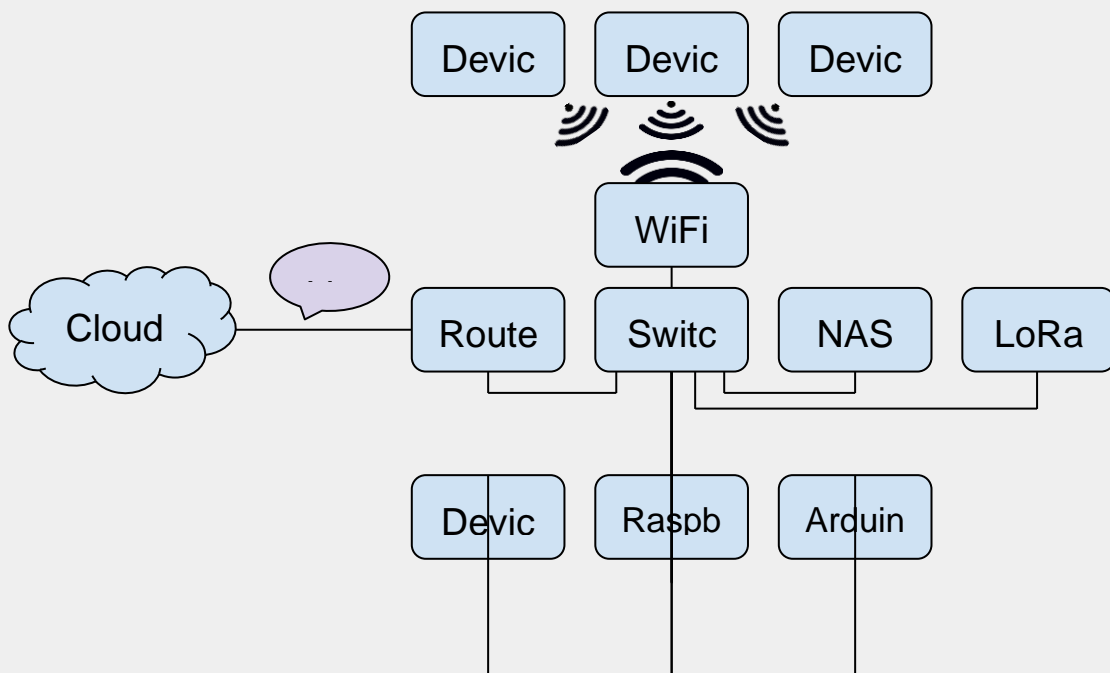
The Raspberry Pi serves as a reliable and affordable platform for experimentation with and learning about IoT. It is a full fledged single board computer with a 40 pin gpio header, which allows interfacing with a wide variety of sensors and actuators. It integrates well with Python, which is the programming language of choice for the DTAM project. Moreover, there are numerous extension modules available for the Raspberry Pi.

11.2 Software

The LAB is build using the following software:

- Synology operating system
- Raspbian (for the raspberry PI cluster)
- Portainer (for running containers on top of the raspberry PI cluster)
- Hadoop
- SSH client
- Python 3 (for working with sensors connected to the GPIO pins)
- VNC (for remotely operating a raspberry PI over the network)
- FortiClient (for connecting a device to the LAB using a VPN connection, provided by Sarenet)

11.3 How to install the lab



The DTAM router needs to be connected to the edge router of your institution and to the DTAM Switch.

The DTAM router needs to be connected to the internal network and have a static or dynamic IP address.

A public IP address needs to be available, so Sarenet can configure the VPN whitelist.

The edge router with public IP needs to forward ports (UDP 4500 & UDP 500) to the DTAM router.

A network engineer needs to check if the VPN connection is up. (In case of problems, please contact Peter Snoek, psnoek@davinci.nl , or Frits Silano, fsilano@davinci.nl for assistance).

If someone wants to connect a laptop or raspberry PI to the DTAM network without physical access to the lab, a FortiClient VPN connection can be setup. Please contact Sarennet (Karmele and/or Mikael) to assist; they can provide a username and password for the VPN client.

11.4 Practical exercises in IoTLab: suggestion and solutions, used devices and materials

As a way to introduce students to the connected DTAM lab, the following exercise could be done. The necessary techniques are explained in module 4 “advanced sensors”.

■ Exercise: European Connected Device

In this assignment you will work in the IoT lab to make a first smart device. You will create a lamp that stays on for 10 seconds after motion is detected. After motion detection you will send the data collected to a database. You will also make a dashboard to see how often the lamp has turned on.

You will work with a Raspberry Pi, PIR and an LED to create the device. You will be working with NodeRed to program the device. Finally, you will work with containers and databases to visualize the generated data.

The transversal skills that come back in this assignment are working in a team and drawing up a planning/division of tasks.

This exercise will cover the following learning outcomes:

- Integrate the production control system with the company's digital management systems.
- Identify the different technologies, architectures and protocols that make an IOT ecosystem possible.
- Design and deploy communications networks for IoT devices, selecting the most appropriate technology.
- Design and program connected devices and use data processing techniques for decision making.
- Do a preliminar assessment of IT/OT network.

Time estimation: 4 hours:

- 1 hour: instruction and feedback
- 3 hours: planning, assembling, programming, communicating and presenting

12 COURSE FINALIZATION

12.1 What is an ECTS?

12.1.1 Introduction

The objective of this guide is to provide the necessary information and tools for applying the ECTS system of credits allocation to the courses and training implemented in the context of the DTAM project. Here, the definition of this common framework for credit recognition adopted in the European Union is going to be presented. In order to fully grasp the importance of the ECTS tool, this Guide will also include an introduction to the ECVET scheme, both closely linked for the recognition and validation of valuable learning experiences completed in different European countries. Such introduction will go through the main components of ECVET, highlighting the links with the ECTS when these are relevant.

12.2 How do they work?

Regarding the application of the ECTS model, crucial importance is recognised to the workload associated with the learning outcome. In fact, the central ratio in the allocation of the credits is the following one:

Full-time workload of an academic year: **60 credits**

It ranges between **1500-1800 hours** for year

Given these parameters, it is possible to define **1 credit as 25-30 hours of work**.

Once this aspect is established, other operation tools are associations with the ECTS. These are the following:

- **Allocation:** the process of assigning a number of credits to qualifications, degree programmes or single educational components;
- **Awarding:** the act of formally granting students and other learners the credits that are assigned to the qualification and/or its components if they achieve the defined learning outcomes;
- **Accumulation:** process of collecting credits awarded for achieving the learning outcomes of educational components in formal contexts and for other learning activities carried out in informal and non-formal contexts.
- **Transfer:** the process of having credits awarded in one context (programme, institution) recognised in another formal context for the purpose of obtaining a qualification.

The last point is particularly relevant if framed in the context also of ECVET, which both works for the harmonization of learning experiences in the European Union and thus facilitating the mobility of many learners regardless of their age, context and qualification they are trying to achieve.

How does the recognition of the credits take place? At the institution level it is recognised that the learning outcomes achieved in another context satisfy the requirements of the programmes the offer, unless it can be proved otherwise. To support this process, a

specific set of standardised documents are usually employed, such as the Learning Agreement, the Transcript of Records etc.

12.3 Introduction to ECVET

The European Credit System for Vocational Education and Training (ECVET) is a technical framework ensuring the smooth transfer, recognition and accumulation of learning outcomes achieved in different countries of the European Union. This process envisages that the students obtain a qualification after the completion and achievement of all the learning outcomes necessary. The general objective of this framework is to make the experience of learning mobility more appealing and overall simpler in the context of lifelong learning.

The framework was established with a Recommendation adopted on June 18th , 2009 by the European Parliament and the Council of the European Union. The document invited European Member States to make the necessary changes in order to create a compatible educational framework allowing the mobility programs to take place in a way that allows students to continue working on their learning process.

In promoting close cooperation between the States regarding their respective educational system, ECVET works for ensuring the transparency of the qualifications granted thanks to an EU-level approach to the recognition of learning outcomes making up such certifications. On the other hand, it provides certain technical tools that are standardized and thus easily shareable among the countries in order to simplify the process of learning outcomes validation.

The main principles and tools of ECVET are summarized here before more details and provided further below:

- Learning Outcomes
- Units of Learning Outcomes
- ECVET Points
- Learning Agreement and Memorandum of Understanding (MoU)

12.4 ECVET Units

Qualifications as intended by the ECVET recommendation and then further elaborated by the Working Group in 2017 should be composed of clearly defined groups of learning outcomes¹ . The same LOs can be part of different qualifications, which makes the ECVET-based approach to the achievement of different certifications a very flexible tools for setting up innovative learning pathways for trainees.

LOs are going to be closely looked at in the following section. However, it is important to highlight here the connection between the ECVET framework and its main tools. LOs represent the goal of the transnational mobility to which the ECVET principles apply. By recognising and validating the LOs, the trainees can work on achieving a qualification in a transnational way efficiently, over a certain period of time. To this end, the ECTS as presented the previous sections are compatible with VET qualifications.

ECVET points are assigned to each learning outcomes in a qualification and represent a numerical value for the weight of said LO. They can be assigned also to whole units or qualifications. Similarly to ECTS, 60 ECVET points are allocated to a full year of formal VET, which is taken as a reference.

12.5 Learning Outcomes

A Learning Outcome, as also introduced for the ECTS, is a coherent set of knowledge, skills and competences which can be assessed and evaluated. It describes the result of a learning process and it represents the basic unit for the achievement of a qualification. Upon completion, the learner masters the three components of which the outcome is composed of. The focus is on what one is able to do (learner's perspective) once they have successfully completed all the units composing the once the LO rather than on what is being taught (educator's perspective).

The achievement of a LO entails the recognition of a certain number of ECVET points, an expression in number of the knowledge associated to the unit. Several units make up each qualification: the learner must accumulate all the required units in order to achieve the desired qualification. Such units can be obtained in a country and then recognised and validated in another one thanks to the application of ECVET principles and tools.

Each LO should be described in legible and understandable terms by referring to the knowledge, skills and competences contained in them. The Recommendation on the European Qualifications Framework – EQF provide the necessary definition for the components of the LOs:

Knowledge: the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. In the context of the European Qualifications Framework, knowledge is described as theoretical and/or factual;

Skills: the ability to apply knowledge and use know-how to complete tasks and solve problems. In the context of the European Qualifications Framework, skills are described as cognitive (involving the use of logical, intuitive and creative thinking) or practical (involving manual dexterity and the use of methods, materials, tools and instruments);

Competences: the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development. In the context of the European Qualifications Framework, competence is described in terms of responsibility and autonomy.

The EQF is also used as a reference for defining the levels of the qualification, along with the specific national framework of reference.

12.6 Evaluation and Assessment

The assessment of each LO should be independent from the rest of the qualification in order to ensure the necessary flexibility for both the achievement of the certification and the recognition of the credits abroad. The goal of the evaluation is that of verifying that the components of the training have been received and that the users is now fully

endowed with the knowledge, skills and competences associated to said LO. Different methods of assessment can be put in place according to the necessities and specificities of each Outcome.

- **Formative assessment:** it provides feedback to learners to adjust learning activities and it is integrated into the learning process;
- **Summative assessment:** it takes place at the end of a programme or module by assessing only a sample of the training, resulting in a mark or a grade for the learner.

A combination of both can be also designed. In any case, it is important that this aspect is holistically approached so to define everything in the inception phase of the Learning Outcome. In practice, the tools available for carrying out the assessment are the following:

- **Written:** tests, examination, assignments;
- **Practical:** skills testing, lab/workshop practice;
- **Oral:** interviews, various formats;
- **Aural:** listening tests;
- **Project work:** individual/group; research/design;
- **Field work:** data collection and reporting;
- **Competence:** threshold standards;
- **Portfolio:** combination of techniques.

A plan can be drafted in order to combine the different aspects of the evaluation and link them with one or more LOs in the same Unit (which is going to be presented later on).

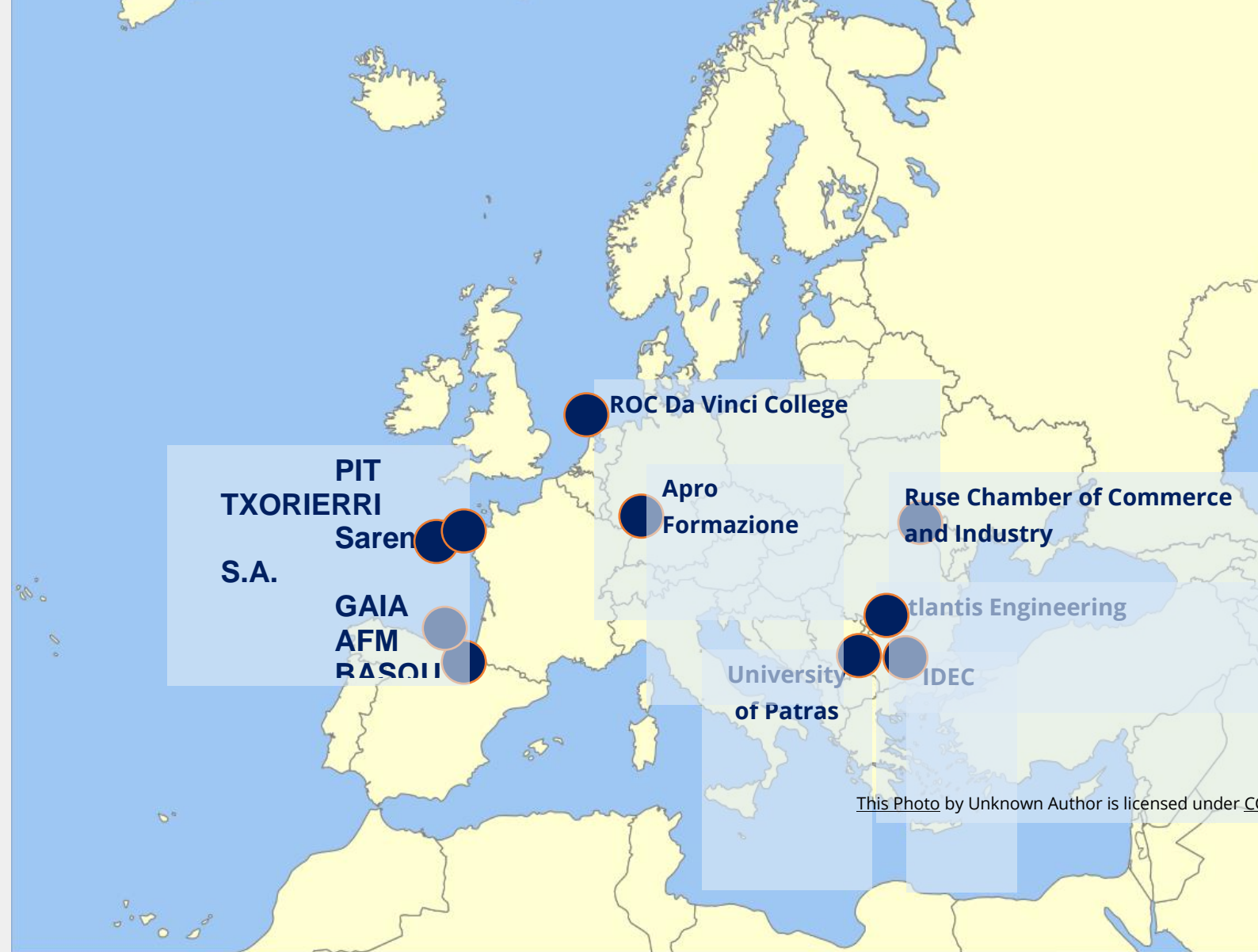
	Assessment Task 1 e.g. Written Exam	Assessment Task 2 e.g. Project	Assessment Task 3 e.g. Presentation	Assessment Task 4 e.g. Lab work
L.O. 1				
L.O. 2				
L.O. 3				

It is important that the evaluation and grading system is fully understood by the learners. To this end, the drafting of a rubric stating the criteria and guidelines of the examination.

L.O.	Assessment Criteria				
	Grade 1	Grade 2:1	Grade 2:2	Pass	Fail
Upon completing this L.O., the learner is able to: [summary]	Outstanding use of literature showing excellent ability to synthesise evidence in analytical way to formulate clear conclusions.	Very good use of literature showing high ability to synthesise evidence in analytical way to formulate clear conclusions.	Good use of literature showing good ability to synthesise evidence in analytical way to formulate clear conclusions	Limited use of literature showing fair ability to synthesise evidence to formulate conclusions.	Poor use of literature showing lack of ability to synthesise evidence to formulate conclusions

This is the example of a LO matrix, explicating all the information for the definition, training/learning activities and assessment

Learning Outcomes	Teaching and Learning Activities	Assessment
<p><i>Cognitive</i> (Demonstrate: Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation)</p> <p><i>Affective</i> (Integration of beliefs, ideas and attitudes)</p> <p><i>Psychomotor</i> (Acquisition of physical skills)</p>	<p>Lectures</p> <p>Tutorials</p> <p>Discussions</p> <p>Laboratory work</p> <p>Clinical work</p> <p>Group work</p> <p>Seminar</p> <p>Peer group presentation etc.</p>	<ul style="list-style-type: none"> • End of module exam. • Multiple choice tests. • Essays. • Reports on lab work and research project. • Interviews/viva. • Practical assessment. • Poster display. • Fieldwork. • Clinical examination. • Presentation. • Portfolio. • Performance. • Project work. • Production of artefact etc.



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