# Semester 5 Modules: Specialization Services, Technologies and Internet of things (ST-IoT)

| code | Title | type | Coeffi-cients | ECTS | Total work-load | Con-tact hours | Pri-vate study |
|---|---|---|---|---|---|---|---|
| ESEP.5.1 | Microcontrollers based Systems | Optional | 2 | 2 | 50 | 30 | 20 |
| ESEP.5.2 | Connected Objects Programming | Optional | 2 | 2 | 50 | 30 | 20 |
| ESEP.5.3 | Cyber-Physical Systems | Optional | 1 | 1 | 25 | 15 | 10 |
| NET.5.1 | Muti-service Cellular Networks | compulsory | 2 | 2 | 50 | 30 | 20 |
| NET.5.2 | communication Architectures and protocols for IoT | compulsory | 2 | 2 | 50 | 30 | 20 |
| NET.5.3 | Networks Management | compulsory | 1 | 1 | 25 | 15 | 10 |
| NET.5.4 | QoS & Trafic eng. | compulsory | 1 | 1 | 25 | 15 | 10 |
| DOS.5.5 | Real time operating systems | compulsory | 2 | 2 | 50 | 30 | 20 |
| DOS.5.6 | Distributed systems and applications | compulsory | 2 | 2 | 50 | 30 | 20 |
| DOS.5.12 | Distributed Storage systems | compulsory | 2 | 2 | 50 | 30 | 20 |
| DOS.5.4 | Advanced architectures and parallel programming | compulsory | 2 | 2 | 50 | 30 | 20 |
| DOS.5.8 | introduction to Cloud computing | compulsory | 1 | 1 | 25 | 15 | 10 |
| IAP.5.3 | Positioning Systems: techniques and Applications | Optional | 1 | 1 | 25 | 15 | 10 |
| DOS.5.11 | IoT Middelware & frameworks | Optional | 1 | 1 | 25 | 15 | 10 |
| DOS.5.2 | Blockchain | Optional | 1 | 1 | 25 | 15 | 10 |
| AI.5.12 | Introduction to Deep Learning | compulsory | 1 | 1 | 25 | 15 | 10 |
| ISA.5.12 | Introduction to Datamining | Optional | 1 | 1 | 25 | 15 | 10 |
| ISA.5.1 | Big Data | Optional | 2 | 2 | 50 | 30 | 20 |
| AI.5.13 | Introduction to Robotics & soft computing | Optional | 2 | 2 | 50 | 30 | 20 |
| SEC.5.2 | IoT Security | compulsory | 2 | 2 | 50 | 30 | 20 |
| SEC.5.4 | IoT security project | Optional | 1 | 1 | 25 | 15 | 10 |
| | Complementary Module 1 | | 2 | 2 | 50 | 30 | 20 |
| | Complementary Module 2 | | 2 | 2 | 50 | 30 | 20 |
| | Complementary Module 3 | | 2 | 2 | 50 | 30 | 20 |
| | Complementary Module 4 | | 1 | 1 | 25 | 15 | 10 |
| | Complementary Module 5 | | 1 | 1 | 25 | 15 | 10 |
| | Complementary Module 6 | | 1 | 1 | 25 | 15 | 10 |

# ESEP.5.1 Microcontrollers based Systems

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| Module designation | ESEP.5.1 Microcontrollers based Systems |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Latrach lassaad<br>Mohamed Masmoudi |
| Teaching team | |
| Language | French |
| Relation to curriculum | Optional |
| Teaching methods | lab works, project |
| Workload (incl. contact hours, self-study hours) | Total workload:50h<br>Contact hours :30h (9h lessons, 21h lab works)<br>Private study:20h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | Analog Ecletronic, Embedded System, Basic programming skills (preferrably C/C++). Hardware: Any STM32 Board |
| Module objectives/intended learning outcomes | Skills: By the end of the course, students will know:<br>● basics of programming for ARM Cortex devices<br>● general principles and approaches to debugging and verification of embedded systems.<br>● perform modeling, optimizing for IOT project<br><br>Competencies: C5, C9 |
| Content | Chapter I – Introduction to ARM® Cortex® (4h)<br>1. Based design. STM32CubeMX<br>2. Compiling, downloading, and running<br>3. simple programs on an evaluation board STM32.<br>Chapter II - Processors and STM-Library – review (HAL/LL) (6)<br>1. tools and libraries (HAL/LL) for STM32-based design<br>2. Programming I/O, investigates some of the functions that configure I/O<br>Chapter III- Peripheral Programming (20h)<br>3. Digital interfaces.<br>4. Graphic LCD Interfacing<br>5. Programming interface<br>UART. I2C, PWM ,ADC SPI, CAN interfaces<br>=>Lab Works (10h) |
| Examination forms | 35% continuous assessment (project and mid-term exam) + 65% written exam |
| Study and examination requirements | 10/20 |
| Reading list | Furber, S. (2000). ARM System-on-Chip Architecture. Pearson Education.<br><br>Yiu, J. (2014). The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors (3rd ed.). Newnes. |

# ESEP.5.2 Connected Objects Programming

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| Module designation | ESEP.5.2 Connected Objects Programming |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Latrach Lassaad |
| Teaching team | |
| Language | French |
| Relation to curriculum | Optional |
| Teaching methods | lab works, project |
| Workload (incl. contact hours, self-study hours) | Total workload:50h<br>Contact hours :30h (15h lesson, 15 h lab works)<br>Private study: 20h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | EHA.4.1- Embedded System<br>EHA.1.2 - Analog Electronics |
| Module objectives/intended learning outcomes | - Know the technical knowledge and skills to build Internet of Things (IoT) systems<br>Skills: programmation des Microcontrôleur ESP32 et raspberry pi avec implémentation sur cloud<br><br>Competencies: C5, C9 |
| Content | Chapter 1 – Embedded Systems, CyberPhysical Systems & IoT<br>Chapter 2 - Sensor & Actuators with ESP32<br>Chapter 3I Embedded Programming<br>Chapter 4 Networking with ESP32 WiFi module and Cloud Platforms for IOT<br>Chapter 4: IoT ecosystems<br>chapter 5: IoT analytics |
| Examination forms | 100% Lab exam |
| Study and examination requirements | 10/20 |
| Reading list | Pfister, C. (2011). Getting Started with the Internet of Things.<br>Ramasamy, L. K., & Kadry, S. (2021). Internet of Things (IoT). |

# ESEP.5.3 Cyber-Physical Systems

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| Module designation | ESEP.5.3 Cyber-Physical Systems |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Chadlia Jerad |
| Teaching team | |
| Language | English |
| Relation to curriculum | Optional |
| Teaching methods | Lesson and Project |
| Workload (incl. contact hours, self-study hours) | Total workload: 50h<br>Contact Hours: 30h (20h lesson, 10h labs )<br>Private study: 20h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | EHA.4.1:Introduction to embedded Systems<br>Automates ; Networking ; Programmation C/C++ ; Programmation JavaScript |
| Module objectives/intended learning outcomes | Knowledge:<br>• Identify a principled, scientific approach to designing and implementing Cyber-Physical Systems, with a focus on model-based system design, and on embedded software.<br>• Skills:<br>• Work with a team<br>• manage time<br>• Systematically take initiative to realize creative ideas<br><br>Competences: C4, C5, C7 |

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| Content | Introduction<br>Chapter 1: Motivation: Cyber Physical Systems<br>• Embedded Systems vs. Cyber Physical Systems<br>• The Hype Cycle; CPS Requirements and challenges<br>• Examples of CPS and IoT applications<br>• IoT Scene; Utility vs. Usability<br>Chapter 2: Model Based Design<br>• Iterative process: modelling, design and analysis<br>• Model based design vs. Statistical methods<br>• The value of models, determinism, Models vs. implementations, Abstraction layers<br>• Models of Computation: State machines, FSM and their composition; Hybrid Automata; Dataflow and KPN<br>• Video Resource: Drone Simulation and Control (https://www.youtube.com/watch?v=gEmGfo36INc)<br>Practical session 1: Practical exercises on Modeling<br>Chapter 3: Sensors and Actuators<br>• Modelling issues with sensors and actuators<br>• Affine Model of Sensors<br>• Bias and Sensitivity<br>• Range and dynamic range ; Precision and quantization<br>• Faults in Sensors ; Sensor fusion<br>• Brief Overview of Actuators<br>Chapter 4: Embedded Systems Programming<br>• Roles of Memory<br>• Memory Architecture issues<br>• Memory organization (statically allocated, stacks, heaps)<br>• Memory hierarchies (scratchpads, caches); Processors; Parallel and serial digital interfaces<br>• IO mechanisms in Software (Polling vs Interrupt) ; Concurrency<br>Reading: Scientific paper selection from the proceedings of “Design Automation Conference”<br>Chapter 5: Networking<br>• Communication technologies and protocols, and their use<br>  • Wired Networks (CAN, TTP, FlexRay, TTEthernet, TSN (a.k.a. AVB))<br>  • Radio technologies (IEEE 802.15.4 (Zigbee, WirelessHART), Bluetooth, NFC)<br>  • 6LowPAN; CoAP<br>  • Ultrasonic ; Visible light ; Vibration<br>• IoT infrastructure and Cloud Service Composition (IFTTT)<br>Chapter 6: IoT Ecosystem<br>• IoT visions, views, characteristics, requirements and building blocks<br>• Reference Architecture for IoT<br>• Resource management in IoT<br>  • Resource partitioning: Container; Virtualization<br>  • Scheduling and provisioning: Cloud vs. Fog<br>  • Resource/Device discovery and selection<br>Chapter 7: IoT Analytics<br>• Publish subscribe for IoT : MQTT<br>  • Sensors reading and actuation<br>  • MQTT broker, clients and topics<br>• Web of Things<br>  • REST<br>  • WoT Integration Patterns: Direct integration Pattern, Gateway Integration Pattern, Cloud Integration Pattern<br>  • CoAP<br>Practical sessions 2:<br>• Lab 1 : Hands-on Node-Red<br>• Lab 2: Simple smart light control<br>• Lab 3 : Hand gesture for smart light control |

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| Examination forms | 40% continuous evaluation +60% written exam |
| Study and examination requirements | 10/20 |
| Reading list | Texbooks :<br>Lee, E. A., & Seshia, S. A. (2015). Introduction to Embedded Systems – A Cyber-Physical Systems Approach (2nd ed.).<br><br>Buyya, R., & Dastjerdi, A. V. (Eds.). (2016). Internet of Things: Principles and Paradigms. Elsevier.<br><br>Ptolemaeus, C. (Ed.). (2014). System Design, Modeling, and Simulation Using Ptolemy II. Ptolemy.org.<br><br>Scientific papers:<br>● Based on “Design Automation Conference” (Class A*) proceedings<br>Tools and frameworks:<br>● Ptolemy II tool:https://ptolemy.berkeley.edu/ptolemyII/ptII11.0/index.htm<br>● Node-Red:https://nodered.org/ |

## NET.5.1 Muti-service Cellular Networks

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| Module designation | NET.5.1 Multi-Service Cellular Networks |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Naouel Ben Salem Grati |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | lesson, exercises |
| Workload (incl. contact hours, self-study hours) | Total workload: 50H<br>Contact hours: 30h (20H Lectures, 10H exercises )<br>Private study: 20h |
| Credit points | 2 ECTS |
| Required and recommended prereq-uisites for joining the module | Existing competences in Réseaux locaux (Net.3.1), TP Réseaux locaux (Net.3.2) and Réseaux informatiques (Net.4.1) |
| Module objectives/intended learning outcomes | Students :<br>● know the difference in architectures between 2G, 4G and 5G networks (focus on security and mobility management).<br>● know the difference in the basic procedures used in 2G, 4G and 5G networks.<br>● Can evaluate the challenges related to the deployment of a simple 2G cellular network under well-defined conditions and scenarios.<br><br>Competencies: C2, C3, C4,C6. |
| Content | <u>Part I : Architecture and protocols of 2G networks</u><br>Lesson 1 (6H)<br>● Cellular communications<br>● Duplex and Multiple Access<br>● Frequency reuse<br>● Network deployment : Health, environmental, economic and technical challenges<br>Lesson 2 (6H)<br>● Components of a 2G cellular network<br>● Identifiers and their uses<br>Lesson 3 (6H)<br>● Security<br>● Location registration and update<br>● Handover and roaming<br>● Call establishment<br><u>Part II : Introduction to 4G networks</u><br>Lesson 4 (6H)<br>● Architecture<br>● Security<br><u>Part II : Introduction to 5G networks</u><br>Lesson 5 (6H)<br>● Massive MIMO<br>● 3D Beamforming<br>● Basic Procedures and Mobility Management |
| Examination forms | 30% Continuous assessment + 70% Written exam |

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| Study and examination requirements | 10/20 |
| Reading list | Hassan, M. (2022). Wireless and Mobile Networking. CRC Press.<br><br>Sauter, M. (2021). From GSM to LTE-Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband. Wiley.<br><br>Eberspächer, J., Vögel, H.-J., Bettstetter, C., & Hartmann, C. (2009). GSM - Architecture, Protocols and Services (3rd ed.). Wiley.<br><br>MOOCs de l'IMT (https://www.youtube.com/c/MOOCdelInstitutMinesT%C3%A9l%C3%A9com) |

## NET.5.2 Communication Architectures and protocols for IoT

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| Module designation | NET.5.2. Communication Architectures and Protocols for IoT |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Hanen Idoudi |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | lecture, labs, exercises, project |
| Workload (incl. contact hours, self-study hours) | Total workload: 50h<br>Contact hours: 30h<br>Private study: 20h |
| Credit points | 2 ECTS |
| Required and recommended pre-requisites for joining the module | Existing competences in networking |
| Module objectives/intended learning outcomes | The purpose of this course is to study the fundamental concepts of Internet of Things. At the end of the course, the students will be able:<br>1. Understand the basic concepts of Internet of Things (IoT)<br>2. Identify the main components of the IoT ecosystem<br>3. Explore the major applications in IoT<br>4. Understand the architecture and protocol stack proposed for IoT<br>5. Set up the specific requirements to design the logic and network architectures of an IoT application<br><br>Competencies: C2, C3, C9 |
| Content | Chapter I – Introduction to the Internet of Things<br>● - The inception of IoT<br>- Basic concepts : smart objects, global connectivity, sensors, etc.<br>- IoT Ecosystem<br>● - IoT challenges<br><br>Chapter II – IoT Applications and architectures<br>● - IoT Applications<br>- IoT architecture layers<br>● - Connectivity models in IoT<br><br>Chapter III – Networks technologies in IoT<br>● IoT networks technologies classification<br>Long range communication networks overview<br>● Short range communication networks overview<br><br>Chapter IV – Middelwares and Application protocols for IoT<br>Web of Things: concepts and communication's models<br>● WoT : Data Standards<br>IoT middelwares<br>Publish/subscribe model<br>WoT : Data exchange protocols<br>MQTT<br>● CoAP<br>Chapter V – Wireeless Sensor networks<br>Chapter VI – Vehicular Ad hoc Networks |
| Examination forms | Labs and final written exam (20%+80%) |

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| Study and examination requirements | To acquires at least 10/20 |
| Reading list | Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A Survey on Enabling Technologies, Protocols and Applications. IEEE Communications Surveys & Tutorials, volume 17, issue 4, 2347 - 2376. |

## NET.5.3 Networks Management

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| Module designation | NET.5.3 Networks Management |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module | Ahmed Elleuch |
| Teachers team | |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | Lesson |
| Workload (incl. contact hours, self-study hours) | Total workload: 25 h<br>Contact hours: 15h lesson<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended prerequisites for joining the module | NET 4.1 Computer Networks<br>NET3.1 Local Area Networks<br>NET.2.1 Digital Transmission |
| Module objectives/intended learning outcomes | Knowledge:<br>Give the students principles and concepts of network management but also a practical and operational vision of network management systems and tools while highlighting their strengths and limitations to solve the main network management problems. This course focuses on SNMP as a standard TCP/IP network management protocol. At the end of the course, the students will :<br>● Understand the concepts and architecture behind SNMP management.<br>● Have knowledge of latest network management tools and systems.<br>Be capable of developing small SNMP programs to perform specific network management tasks.<br><br>Competencies: C1, C2, C13 |
| Content | Basic Foundations<br>Definitions, Scope and Issues<br>Models, Architectures and Standards<br>SNMP Network Management<br>Concepts, Architecture and Protocol (SNMP v1 v2c and v3)<br>Structure of Management Information (ASN.1, SMI BER …)<br>Object Identifiers and Instance Identification<br>Management Information Base (MIB-II, RMON) and MIB Browsing<br>SNMP Authentication and Access Control<br>SNMP Programming<br>Alternatives and complementary Solutions<br>CLI, WBEM, WMI<br>NETCONF/YANG, RESTCONF<br>NETFLOW/IPFIX<br>Tools and Network Management Systems<br>Main functions of Network Management Systems and Tools<br>● NET-SNMP, RRDtools, Cacti, Nagios, HP Openview … |
| Examination forms | written exam |

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| Study and examination require-ments | 10/20 |
| Reading list | Burke, J. R. (2004). Network Management: Concepts and Practice: A Hands-on Approach. Prentice Hall.<br><br>Stallings, W. (2005). SNMP, SNMPv2, SNMPv3 and RMON 1 and 2 (3rd ed.). Addison Wesley Inc. |

## NET.5.4 QoS & Trafic Engineering

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| Module designation | NET.5.4 QoS and Trafic Engineering |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Chiraz Houaidia |
| Language | French |
| Relation to curriculum | compulsory |
| Teaching methods | lesson, classroom exercices, presentations, … |
| Workload (incl. contact hours, self-study hours) | Total workload: 25h<br>Contact hours: 15h (10h lessons, 5h labs/classroom exercices)<br>Private study: 15h |
| Credit points | 1 ECTS |
| Required and recommended pre-requisites for joining the module | Local Networks<br>Computer networks |
| Module objectives/intended learning outcomes | At the end of the course, the students will :<br>● Master the various engineering mechanisms and approaches related to the performance of wired, wireless and mobile networks, particularly in terms of sizing, resource allocation and control.<br>● Knowing how to use techniques and tools to plan, implement and develop architectures capable of providing quality of service depending on the types of applications.<br><br>Competencies: C4, C5, C8 |
| Content | I. Mono-service networks:<br>1. Sizing in fixed and mobile telephone networks<br>2. Congestion control, scheduling and dimensioning in best-effort IP networks<br>II. Multi-service IP networks:<br>1. Quality of Service Paradigms in Multiservice IP Networks<br>2. Advanced techniques (advanced congestion control, active queue management, etc.)<br>3. Flow level modelling and quality of service<br>III. Wireless and mobile networks:<br>1. Quality of services in cellular networks (3G, 4G, 5G)<br>2. Quality of service in wireless networks (personal, local, metropolitan, regional |
| Examination forms | 30% continuous assessment (tutorials, lab works) + 70% written exam |
| Study and examination requirements | 10/20 |

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| Reading list | Agiwal, M., Roy, A., & Saxena, N. (2016). Next generation 5G wireless networks: A comprehensive survey. IEEE Communications Surveys and Tutorials, 18(3).<br><br>Panwar, N., Sharma, S., & Singh, A. K. (2016). A survey on 5G: The next generation of mobile communication. Physical Communication, 18.<br><br>Mitra, R. N., & Agrawal, D. P. (2015). 5G mobile technology: A survey. ICT Express, 1.<br><br>SP-150149, “5G” timeline in 3GPP.<br><br>Flore, D. (Chairman of 3GPP RAN), Qualcomm Technologies Inc. (2016). LTE evolution and 5G. Presented at Broadband World Forum 2016.<br><br>Scrase, A. (ETSI CTO). (2016). 5G from Myth to Reality: The why, when, where, what and how of 5G standards. Presented at Broadband World Forum, London. |

## DOS.5.5 Real time operating systems

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| Module designation | DOS.5.5 Real time operating systems |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (co-ordinator ) + team | (Latrach lassaad), Mohamed Karim Bouafoura, Jerad chedlia, Masmoudi Mohamed |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | lab works, project |
| Workload (incl. contact hours, self-study hours) | Total workload:50h<br>Contact hours : 30h (9h lessons, 21h lab works)<br>Private study: 20h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | Embedded System, operating system, Basic programming skills (preferrably C/C++).Hardware: Any STM32 Board |
| Module objectives/intended learning outcomes | Key question: what learning outcomes should students attain in the module?<br>E.g. in terms of:<br>● Knowledge: understand problems related to real-time applications and operating systems;<br>● understand how to use real-time operating systems following the FreeRtos<br>● Skills: Develop an Embedded Real Time software<br>● Design real-time applications using freeRTOS Build real-time<br><br>Competencies: C7, C8, C13 |
| Content | Chapter I – Introduction<br>7. Introduction to Real-time systems and Embedded Real-time<br>8. Design objective for Real-time software<br>9. RTOS Task and Task state<br>Chapter II - Real-time operating systems<br><br>10. Basic principles<br>11. Scheduling algorithms for periodic tasks: Rate Monotonic, Earliest Deadline First, Deadline Monotonic;<br>12. Scheduling algorithms for aperiodic tasks: schedulazione in background, Polling Server, Deferrable Server;<br>Chapter III- System architecture of freeRTOS<br>13. Introduction to FreeRTOS<br>14. Task Management in Free RTOS<br>15. Synchronization in FreeRTOS<br>16. Creating FreeRTOS based project for STM32 MCUs<br>17. Inter Task Communication (FreeRTOS Queue)<br>18. Semaphores and Mutex (FreeRTOS)<br><br>=>Lab Works (10h) |
| Examination forms | 35% continuous assessment (project and mid-term exam) + 65% written exam |

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| Study and examination requirements | 10/20 |
| Reading list | Buttazzo, Giorgio C.  Hard Real-time Computing Systems, Kluwer Academic publishers,<br><br>Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools<br><br>Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools<br>, |

## DOS.5.6 Distributed Systems and Applications

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| Module designation | DOS.5.6 Distributed Systems and Applications |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Faïza NAJJAR |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | Lessons, lab works, exercises & mini-project |
| Workload (incl. contact hours, self-study hours) | Total workload: 50H<br>Contact hours: 30H (20H lessons, 10H lab works)<br>Private study: 20H |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | Operating systems and Concurrent Programming (OS.3.03)<br>Object-oriented Programming (AP.2.1) |
| Module objectives/intended learning outcomes | Objectives:<br>With the omnipresence of distributed, multi-users and open computing, running constantly under different wide variations of platforms, this module provides a good comprehensive on fundamental concepts and issues of distributed systems. In particular, it masters in depth practical of the client-server programming applications and services upon (standard) middlewares (synchronous, asynchronous, transient, and persistent communications) with common and newest technologies.<br><br>Competencies: C7, C8 |

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| Content | CHAP. 1. Client-server Programming (2 weeks)<br>● Introduction to distributed systems: basics concepts; architectures (C/S with request/response; Master-slaves; P2P; …)<br>● Client-server model: definitions; characteristics. (synchronous/asynchronous) communication<br>● Programming C/S with Remote Procedure Call (RPC): Interface description language –IDL; stubs; marshalling; binding; portmapper; XDR.<br>LAB: C/S PROGRAMMING with RPC<br>● Synchronous Programming on laptops (with C on Linux)<br><br>CHAP.2. gRPC Programming (1,5 weeks)<br>● Data serialization and Google protocol buffers –protobuf<br>● Message description Language ( *.proto files)<br>● Message Encodage<br>● gRPC principles (https://grpc.io/)<br>● IDL Grpc; protoc compiler (from .proto to code)<br>Programming Assignment:<br>● HelloWorld Application C/S (laptop & Smartphone-Android) with at least two different languages (Go; java; …).<br><br>CHAP. 3 Message-oriented Middleware (MOM) (1 week)<br>● Communication types (Synchronous vs. Asynchronous ; Transient vs. Persistent)<br>● High-level middleware communication services: Point-to-point; Message queueing --MQ; publish-subscribe –pub-sub; pull and push delivery.<br>● MOM technology Java-message service –JMS.<br>Mini-project: Asynchronous distributed programming with open MQ<br><br>CHAP. 4. Peer-to-Peer systems and applications (2 weeks)<br>● Motivations: skype, Spotify, BitTorrent, ...<br>● Overlays on networks; Research issues (lookup/discovery, connectivity, communication, security, …).<br>● Types of P2P: centralized; decentralized; hybrid; semantic.<br>● Examples of P2P systems and applications:<br>● Distributed Hash table –DHT (on Chord)<br>HOMEWORK : exercises on DHT<br><br>CHAP. 5. Distributed file systems (2,5 weeks)<br>● Services and protocols<br>● A standard DFS: NFS<br>● A large scale DFS: HDFS<br>● Introduction to Big data<br>● Google FS –GFS: Master-slave architecture; Chunk; chunkserver; map-reduce distributed programming model.<br>● Hadoop distributed file systems: Namenode, Datanodes; JoTtracker, TaskTrackers; hdfs shells<br>Mini-project: WordCount application with Hadoop map-reduce and hdfs<br>Recapitulation (Review) and Cutting edge IT (last lesson before final exam) |

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| Examination forms | 40% CW + 60% Final Exam<br>with CW -- Continuous work =Mean(test; (programming) assignments, Home-Works; classroom exercises) |
| Study and examination requirements | 10/20 |
| Recommended readings | • A. S. Tanenbaum, M. V. Steen, Distributed Systems: Principles and Paradigms, Createspace Independent Pub; 2nd edition (26 February 2016), ISBN-10: 153028175X (ISBN-13: 978-1530281756). Free download onhttps://www.distributed-systems.net/index.php/books/ds3/ (third edition, 2017).<br>• Max Hailperin, Operating Systems and Middleware: Supporting Controlled Interaction, Revised Edition 1.3.1, Max Hailperin, June 4, 2019<br>• Indranil Gupta, Advanced distributed systems, P2P systems, Spring 2018<br>• Martin Crane, Messaging on Distributed Systems (CA4006) LN (2017) (http://www.computing.dcu.ie/~mcrane/CA4006) |

# DOS.5.12 Distributed Storage Systems

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| Module designation | DOS.5.12 Distributed Storage Systems |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Raoudha KHCHERIF |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | lecture, lesson, assignment, labs |
| Workload (incl. contact hours, self-study hours) | Total workload: 50 h<br>Contact hours: 30 h<br>Private study: 20 h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | DAT.2.1 , DAT.2.2, NET3.1, NET3.2, NET4.1 |
| Module objectives/intended learning outcomes | This course will deal with the fundamental issues in large distributed database systems which are motivated by the computer networking and distribution of processors, and control. The theory, design, specification, implementation, and performance large systems will be discussed.<br><br>Competencies: C1, C2, C8, C13 |
| Content | I INTRODUCTION<br>II. BDR DESIGN<br>I. BDR By Practice<br>III. TRANSACTION AND COMPETITOR ACCESS<br>IV. OPTIMIZATION OF DISTRIBUTED QUERIES<br>V. OPERATING SAFETY<br>VI. RDBMS ARCHITECTURE |

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| Examination forms | 100% written Exam |
| Study and examination requirements | 10/20 |
| Reading list | Özsu, M. T., & Valduriez, P. (2011). Principles of Distributed Database Systems (846 pages). Springer.<br><br>Rahimi, S. K. (2010). Distributed Database Management Systems. John Wiley & Sons Inc. |

# DOS.5.4 Advanced Architectures and Parallel Programming

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| Module designation | DOS.5.4 Advanced Architectures and Parallel Programming |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Lobna KRIAA |
| Teaching team | Chadlia Jerad |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | Lesson & lab work. |
| Workload (incl. contact hours, self-study hours) | Total workload: 50h<br>Contact hours: 30h (15.5h lessons, 5 hours exercises, 0.5h oral presentations, 9h labs)<br>Private study:20h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | EHA.2.1: Architecture & microprocessors<br>EHA.3.1: Processor Design Methodology<br>AP.1.3: Advanced C<br>AP.2.1: Object-Oriented programming<br>OS.3.03: Operating systems and concurrent programming<br>Existing competencies: curiosity, autonomy |
| Module objectives/intended learning outcomes | • Knowledge:<br>• Showcasing parallel architectures (advantages and disadvantages)<br>• Ability to evaluate and analyse performances of different architectures (parallel and optimized)<br>• Learning about parallel programming<br>• Skills: Students know how to think parallel and try to write parallel programs<br><br>Competencies: C5, C8, C13 |

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| Content | General Introduction<br>Section I: Limits of classical architectures<br>Section II: Definition of parallelism<br>Section III Characteristics of parallel architectures<br>Chapter I: Classification of Parallel Machines<br>Section I: Flynn's classification (SISD, SIMD, MIMD)<br>Section II: Raina's classification<br>- Exercises related to SIMD and MIMD architectures (about 1h)<br>Chapter II: Performance of computer architectures<br>Section I: Importance of performance calculation<br>Section II: Amdahl's law/Gustafson's law<br>Section III: Units of performance measurement<br>Section IV: SPEC standard<br>- Exercises related to performance (about 2h with discussions)<br>Chapter III: Cache coherence for parallel architectures<br>Section I: Memory Cache<br>o Definition<br>o Type of cache memory mapping<br>o Write problem<br>Section II: Cache coherence protocols<br>o Snoopy Bus<br>o Directory-based protocols<br>- Exercises related to performance (about 2h with discussions)<br><br>Chapter IV: Basic Concepts for Parallel Programming<br>Section I: Basic concepts<br>Section II: Sharing for what purpose?<br>Section III: Data Concurrency and Synchronization<br>Chapter V : Programming with OpenMP<br>- Introduction to OpenMP<br>Section II: Studies of OpenMP pragmas<br>- Private Variables vs Shared Variables<br>- Parallel tasks<br>- This chapter is fed by practical labs for each concept studied (about 9h)<br>o Realization of the tests<br>o Analysis of the results<br>* Students in this context must choose another parallel programming model or language and make a presentation focusing on the parallel paradigm or concept offered by the chosen language |
| Examination forms | 35% continuous evaluation + 65% written exam |
| Study and examination requirements | 10/20 |

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| Reading list | Hennessy, J. L., & Patterson, D. A. (2021). Computer organization and design risc-v edition: The hardware software interface.<br><br>Quemener, E. (2021, November). Des architectures parallèles aux programmes parallélisés - De la métrologie à la mesure de la performance. [Online course]. DOI:10.13140/RG.2.2.23467.72483<br><br>Ayguadé, E., Copty, N., Duran, A., Hoeflinger, J., Lin, Y., Massaioli, F., ... & Zhang, G. (2008). The design of OpenMP tasks. IEEE Transactions on Parallel and Distributed Systems, 20(3), 404-418.<br><br>Reed, D., Gannon, D., & Dongarra, J. (2022). Reinventing High Performance Computing: Challenges and Opportunities. arXiv preprint arXiv:2203.02544.<br><br>OpenMP. (n.d.). Retrieved October 2022, from https://www.openmp.org/ |

## DOS.5.8 Introduction to Cloud Computing

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| Module designation | DOS.5.8 Introduction to Cloud Computing |
| Semester(s) in which the module is taught | 5 |
| Person responsible for the module (coordinator) | Dr. Mehrez Essafi |
| Teaching team | - |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | • Lesson<br>• Lab work |
| Workload (incl. contact hours, self-study hours) | Total workload: 25h<br>Contact hours: 15h (12h lessons, 3h lab work)<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended prerequisites for joining the module | OS.2.1 Introduction to Operating systems and Unix environment<br>NET.3.1 Local Networks<br>NET.4.1 Computer Networks<br>SE.4.2 Software Architecture<br>SEC.4.1 Cybersecurity & cryptography |
| Module objectives/intended learning outcomes | • To understand the related architecture designs and technologies of cloud computing<br>• To explain the overall architecture and key design principles of IoT systems, including both functional and non-functional aspects<br>• To design cloud-based IoT applications using proper cloud services<br>• To gain hands-on experience in key technologies for developing an IoT system, including sensor selection / interfacing, embedded system programming, use of suitable network protocols, and various cloud services (compute, storage, data analytics, management)<br>• To gain design experience in solving a real-world problem using IoT and cloud technologies<br>• To gain both the experience and confidence in learning a new IoT technology independently<br>By the end of the course, students are expected to be able to:<br>• Describe the IoT and Cloud architectures.<br>• Deploy Cloud Services using different cloud technologies.<br>• Implement cloud computing elements such virtual machines, web apps, mobileservices, etc.<br>• Establish data migration techniques from IoT devices to the cloud.<br>• Implement security features to protect data stored in the cloud.<br>• Use visualisation techniques to show data generated from the IoT device.<br><br>Competencies: C2, C3, C4, C5, C6, C13 |

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| Content | Unit 1 – Cloud Computing: main concepts<br>● General introduction<br>● Historical overview<br>● Cloud characteristics<br>● Business model<br>● Advantages and limits<br>Unit 2 – Data centers<br>● Definitions<br>● Main components<br>● Green Computing<br>● Security<br>● High Availability<br>Unit 3 – Cloud Services and deployment models<br>● IaaS (Infrastructure as a Service)<br>● PaaS (Platform as a Service)<br>● SaaS (Software as a Service)<br>● FaaS (Function as a Service)<br>● Other services<br>● Public Cloud<br>● Private Cloud<br>● Hybrid Cloud<br>● Community Cloud<br>Unit 4 – Virtualization<br>● Definitions<br>● Architectures<br>● Solutions<br>● Servers virtualization<br>● Containers<br>● Storage virtualization<br>Unit 5 – Application of IoT & Cloud<br>● IoT and cloud integration<br>● Application development and cloud processing<br>● Security and Privacy for IoT/Cloud Computing |
| Examination forms | ● 20% labs & 80% written examination |
| Study and examination requirements | Student must achieve an overall minimum module mark of 10/20 |

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| Reading list | Mell, P., & Grance, T. (2011). The NIST Definition of Cloud Computing (800-145). National Institute of Standards and Technology (NIST).<br><br>Duncan, C. H. (2017). Cloud computing gateway, cloud computing hypervisor, and methods. International Conference on Cloud Computing.<br><br>Hennion, R., Tournier, H., & Bourgeois, E. (2014). Cloud computing : Décider - Concevoir - Piloter – Améliorer.<br><br>Plouin, G. (2014). Cloud Computing, Sécurité, stratégie d'entreprise et panorama du marché. Collection InfoPro, Dunod.<br><br>Rapport Cigref. (2013). Fondamentaux du Cloud Computing : Le point de vue des Grandes Entreprises.<br><br>Moyer, C. M. (2011). Building Applications in the Cloud : Concepts, Patterns, and Projects. Addison-Wesley.<br><br>Marks, E. A., & Lozano, B. (2010). Executive's Guide to Cloud Computing. Wiley.<br><br>Fagroud, F. Z., Benlahmar, E. H., Elfilali, S., & Toumi, H. (2019). IOT et Cloud Computing : état de l'art. Colloque sur les Objets et systèmes Connectés, Ecole Supérieure de Technologie de Casablanca (Maroc), Institut Universitaire de Technologie d'Aix-Marseille (France), CASABLANCA, Maroc.<br><br>Odun-Ayo, I., Okereke, C., & Evwieroghene, O. (2018). Cloud Computing and Internet of Things - Issues and Developments.<br><br>Christos, S., Kostas, P., Byung-Gyu, K., & Gupta, B. B. (2016). Secure Integration of Internet-of-Things and Cloud Computing. Future Generation Computer Systems.<br><br>Vertiv. (2018). L'impact du cloud et de l'internet des objets sur la demande en datacenters, Livre blanc et noir. |

# IAP.5.3 Positioning Systems: techniques and Applications

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| Module designation | IAP.5.3 Positioning Systems, Techniques and Applications |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Faïza NAJJAR |
| Language | English |
| Relation to curriculum | Optional |
| Teaching methods | Lessons, mini-projects and research presentations |
| Workload (incl. contact hours, self-study hours) | Total workload: 25H<br>Contact hours (lectures, (classroom/homework) exercises, lab. System programming): 15H (10H lessons, 5H presentations)<br>Private study: 10H |
| Credit points | 1 ECTS |
| Required and recommended prereq-uisites for joining the module | Mobile communication and networks<br>Advanced Networks |
| Module objectives/intended learning outcomes | Objectives:<br>This course is a special interest of mobile and sensor computing; it will introduce fundamentals and theoretical foundations of location-based services (LBS), including the most common services such as wireless localization, tracking and navigation on outdoor (e.g. GNSS) and a special emphasis on indoor LBS (e.g. WiFi-based).<br>Students may undertake projects with real world data to put in practice the knowledge acquired in wireless positioning techniques and algorithms.<br><br>Competencies: C2, C3, C4,C6. |
| Content | 1. Location based services –LBS: Fundamentals: Location; Mobile Technologies, techniques (proximity; trilateration; fingerprinting); Reference systems; outdoor, indoor<br>2. Introduction to Satellite-based systems --GNSS<br>● Examples of GNSS (GPS, Glonass, Beidou, …)<br>● Principles of the Global Positioning System<br>● Programming assignment -Mini-Project:<br>● Applications of GPS on Android Smartphones<br>● Hot GNSS-based services?<br>3. Indoor localization<br>● Classification<br>● MEMS and multi-sensor positioning<br>● Indoor map construction (standards)<br>● Pedestrian positioning systems: examples<br>● Lab. RSS-fingerprinting localization<br>4. Indoor Pedestrian Navigation using Smartphone: from research to production<br>● Architecture of navigation Systems (Cartography, Pathfinding, guiding)<br>● Mini-Project: WiFi-based navigation (ENSI) |

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| Grading (Total 20 points) | 35% CW + 65% Final Exam<br>with CW --Continuous work = Mean (classroom exercises; Mini-projects; presentation) |
| Study and examination requirements | 10/20 |
| References | 1. Data Management for Mobile Computing, Evaggelia Pitoura and George Samaras , Kluwer Academic Publishers, 1998 ,ISBN: 0-7923-8053-3<br>2. Alkhawaja, Fares & Jaradat, Mohammad & Romdhane, Lotfi. (2019). Techniques of Indoor Positioning Systems (IPS): A Survey. 1-8. 10.1109/ICASET.2019.8714291.<br>3. K. -J. Li, S. Zlatanova, J. Torres-Sospedra, A. Perez-Navarro, C. Laoudias and A. Moreira, "Survey on Indoor Map Standards and Formats," 2019 International Conference on Indoor Positioning and Indoor Navigation (IPIN), 2019, pp. 1-8, doi: 10.1109/IPIN.2019.8911796.<br>4. A. Billa, I. Shayea, A. Alhammadi, Q. Abdullah and M. Roslee, "An Overview of Indoor Localization Technologies: Toward IoT Navigation Services," 2020 IEEE 5th International Symposium on Telecommunication Technologies (ISTT), 2020, pp. 76-81, doi: 10.1109/ISTT50966.2020.9279369. |

# DOS.5.11 IoT Middelwares &Frameworks

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| Module designation | DOS.5.11 IoT Middlewares & Frameworks |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Faiza Najjar & Chiraz Houaidia |
| Language | French |
| Relation to curriculum | optional |
| Teaching methods | lesson, lab works |
| Workload (incl. contact hours, self-study hours) | Total workload: 25h<br>Contact hours: 15h (10h lessons, 5h lab works)<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended pre-requisites for joining the module | Introduction to OS and Unix Environment Operating systems and concurrent programming<br>networks and C / JAVA language<br>introduction to distributed systems and applications |
| Module objectives/intended learning outcomes | Knowledge:<br>At the end of the course, the students will :<br>● Acquire and use knowledge of distributed systems<br>● Discover the main concepts of middleware and distinguish between the different types<br>● Learn how to build a distributed application using different (recent) technologies.<br><br>Competencies: C4, C5, C8 |
| Content | 1. General introduction to middleware and distributed applications<br>2. Designation and Linkage in distributed systems<br>DNS<br>LDAP<br>JNDI<br>3. Web services architectures<br>SOAP<br>REST<br>4. Event-Oriented Middleware<br>MQTT<br>5. Middleware for mobile, ubiquitous and pervasive environments |
| Examination forms | 30% continuous assessment (lab works) + 70% written exam |
| Study and examination requirements | 10/20 |

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| Reading list | Tanenbaum, A. S., & van Steen, M. (2006). Distributed Systems: Principles and Paradigms (2nd ed.). Prentice Hall.<br><br>Schmidt, D. C., & Buschmann, F. (2003). Patterns, frameworks, and middleware: Their synergistic relationships. In 25th International Conference on Software Engineering (pp. 694–704). Portland, Oregon.<br><br>Integration in the Internet of Things: A semantic middleware approach to seamless integration of heterogeneous technologies. (2016). Elsevier.<br><br>Middleware Architecture with Patterns and Frameworks. (2009). |

## DOS.5.2 Blockchain

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| Module designation | DOS.5.2 Blockchain |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module | Mohamed Houcine Hdhili, Hanen Idoudi |
| Teachers team | Hanen Idoudi |
| Language | French |
| Relation to curriculum | Optional |
| Teaching methods | Lesson, Lab works |
| Workload (incl. contact hours, self-study hours) | Total workload:25h<br>Contact hours: 15h (9h lesson, 6h lab works)<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended pre-requisites for joining the module | SEC.4.1 Cybersecurity and Cryptography |
| Module objectives/intended learning outcomes | Knowledge:<br>After completing this course, students should be able to:<br>• Explain blockchain and how it is applied across industries.<br>• Describe key principles of blockchain technology and the benefits and value that they bring to enterprises.<br>• Explain the role of a shared ledger.<br>• Explain fundamental concepts in Hyperledger Fabric.<br>• Describe the elements of a business network, the role of channels, and how the world state is maintained.<br>• Develop, test, debug, and deploy chaincode with IBM Blockchain Platform Extension for Visual Studio Code<br>• Apply concepts of blockchain security, identity and access control, and data privacy to blockchain solutions.<br>• Write applications that interact with a blockchain network.<br>• Describe patterns, best practices, and reference architectures for integration from enterprise applications to blockchain networks.<br><br>Competencies: C6, C13 |
| Content | Unit 1. Blockchain overview<br>Unit 2. Introduction to chaincode development<br>Unit 3. Chaincode query methods<br>Unit 4. Best practices for writing, testing, and debugging chaincode<br>Unit 5. Identity and access control<br>Unit 6. Data privacy<br>Unit 7. Basics of application development<br>Unit 8. Blockchain integration and advanced application development |
| Examination forms | 100% written exam |
| Study and examination requirements | 10/20 |
| Reading list | IBM Blockchain Developer – Official course material |

## AI.5.12 Introduction to Deep Learning

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| Module designation | AI.5.12 Introduction to Deep Learning |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Rym Besrour |
| Teaching team | Rym Besrour |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | Lesson and project |
| Workload (incl. contact hours, self-study hours) | Total workload: 25h<br>Contact hours: 15h lessons<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended pre-requisites for joining the module | MAT.1.1: Probability and Statistics<br>AI .3.1.: IA & Machine Learning<br>Students must be competent in python. |
| Module objectives/intended learning outcomes | • Knowledge:<br>  • Understand generic machine learning terminology<br>  • Understand motivation and functioning of the most common types of deep neural networks<br>  • Understand the choices and limitations of a model for a given setting<br>  • Apply deep learning techniques to practical problems<br>  • Critically evaluate model performance and interpret results<br><br>Competences: C1, C9 |
| Content | Introduction<br>Chapter1:Applied Math and Machine Learning Basics<br>  • Linear Algebra<br>  • Probability and Information Theory<br>  • Numerical Computation<br>  • Machine Learning Basics<br>Chapter2:Modern Practical Deep Networks<br>  • Deep Feedforward Networks<br>  • Regularization for Deep Learning<br>  • Optimization for Training Deep Models<br>  • Convolutional Networks<br>  • Sequence Modeling: Recurrent and Recursive Nets<br>  • Practical Methodology<br>  • Applications<br>Chapter3 :Deep Learning Research<br>  • Autoencoders<br>  • Deep Generative Models<br><br>Projects ideas :<br>  • Smart routing<br>  • Smart home security<br>  • Smart energy managment |

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| Examination forms | 100% project evaluation |
| Study and examination require-ments | 10/20 |
| Reading list | Géron, A. (2020). Deep Learning avec Keras et TensorFlow (2nd ed.). Dunod.<br>Charniak, E. (2021). Introduction au Deep Learning. Dunod. |

# ISA.5.12 Introduction to Data Mining

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| Module designation | ISA.5.12 Introduction to Data Mining |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Rym Besrour |
| Language | French |
| Relation to curriculum | optional |
| Teaching methods | lesson, project. |
| Workload (incl. contact hours, self-study hours) | Total workload: 25h<br>Contact hours: 15h lessons<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended prerequisites for joining the module | MAT.1.1: Probability and Statistics<br>AI .3.1.: IA & Machine Learning<br>Students must be competent in python. |
| Module objectives/intended learning outcomes | Knowledge:<br>● To introduce students to the basic concepts and techniques of Data Mining.<br>● To develop skills of using recent data mining software for solving practical problems.<br>● To gain experience of doing independent study and research.<br><br>Competences: C1, C9 |
| Content | Chapter1: Introduction to Data Mining<br>● What is data mining?<br>● Related technologies - Machine Learning, OLAP, Statistics<br>● Data Mining Goals<br>● Stages of the Data Mining Process<br>● Data Mining Techniques<br>● Knowledge Representation Methods<br>● Applications<br>Chapter2: Data preprocessing<br>● Data cleaning<br>● Data transformation<br>● Data reduction<br>● Discretization and generating concept hierarchies<br>Chapter3: Association rules<br>● Motivation and terminology<br>● Example: mining weather data<br>● Basic idea: item sets<br>● Generating item sets and rules efficiently<br>● Correlation analysis<br>Chapter4 : Clustering<br>● Basic issues in clustering<br>● First conceptual clustering system: Cluster/2<br>● Partitioning methods: k-means, expectation maximization (EM) |

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| | • Hierarchical methods: distance-based agglomerative and divisible clustering<br>Projects ideas :<br>• Text mining: extracting attributes (keywords), structural approaches (parsing, soft parsing).<br>• Bayesian approach to classifying text<br>• Web mining: classifying web pages, extracting knowledge from the web |
| Examination forms | 100% Lab exam |
| Study and examination requirements | 10/20 |
| Reading list | Han, J., & Kamber, M. (2011). Data Mining: Concepts and Techniques. Morgan Kaufmann ; 3rd edition. |

## ISA.5.1 Big Data

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| Module designation | ISA.5.1 Big Data |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Raoudha Chebil |
| Language | French |
| Relation to curriculum | Optional |
| Teaching methods | lesson, lab works, presentations. |
| Workload (incl. contact hours, self-study hours) | Total workload: 50 hours<br>Contact hours: 30 hours: 20 hours lessons + 10 hours lab works<br>Private study: 20 hours |
| Credit points | 2 ECTS |
| Required and recommended pre-requisites for joining the module | Basic knowledge in programming (Python and Java) and relational data-bases |
| Module objectives/intended learning outcomes | Knowledge: Students:<br>-Master the basic building blocks of the Hadoop platform, namely HDFS and MapReduce, and have an idea of the components of its ecosystem;<br>-Master the MapReduce approach for problem solving;<br>-Understand the limits of the relational model and know the different models of NOSQL databases.<br><br>Competences: C4, C7, C8 |

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| Content | Chapter I – Introduction to Big Data<br>1. Motivations<br>2. Definition<br>3. The 3Vs and the additional Vs<br>4. Benefits and challenges<br>5. Application examples<br>6. Stages of a Big Data project<br>7. New professions<br>8. Related fields<br>Chapter II – Hadoop: Building Blocks<br>1. Hadoop presentation<br>2. Hadoop history<br>3. Hadoop ecosystem<br>4. HDFS<br>5. MapReduce V1<br>6. MapReduce V2<br>7. Design Patterns MapReduce<br>Chapter III - Advanced Processing Tools<br>1. Data processing types<br>2. MapReduce review<br>3. Abstraction languages<br>a. Pig<br>b. Hive<br>4. Apache Spark<br>Chapter IV – NOSQL Databases<br>1. DBMS strengths<br>2. DBMS limits<br>3. BD NOSQL<br>4. BDR vs BD NOSQL<br>5. Study of BD NOSQL instances<br>a. Cassandra<br>b. MongoDB<br>Chapter V – Big Data Architectures<br>1. Motivations<br>2. Lambda architecture<br>3. Kappa architecture<br>4. Other architectures<br>5. Case study<br><br>Practical Works<br>1. Installation and testing of the working environment<br>2. HDFS<br>3. MapReduce<br>4. Pig and Hive<br>5. Spark<br>6. HBase |
| Examination forms | 35% continuous evaluation (Lab works, presentations) ; 65% written exam |
| Study and examination require-ments | 10/20 |

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| Reading list | Mooc<br>● "Fundamentals for Big Data", Télécom ParisTech<br>● "Introduction to Hadoop and MapReduce", University Nice Sophia Antipolis<br>Books<br>Bruchez, R. (2015). NoSQL databases and BigData: Understanding and implementing. Editions Eyrolles.<br><br>Marr, B. (2015). Big Data: Using SMART big data, analytics and metrics to make better decisions and improve performance. John Wiley & Sons.<br><br>Zikopoulos, P., Eaton, C., et al. (2011). Understanding big data: Analytics for enterprise class hadoop and streaming data. McGraw-Hill Osborne Media.<br><br>Classes<br>NERZIC, Pierre. Hadoop tools for Big Data. Rennes1 University, FRANCE, 2016. |

## AI.5.5 Robotics & soft computing

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|---|---|
| Module designation | AI.5.5 Robotics & Soft Computing |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module (coordinator) | Moncef TAGINA |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | lesson, lab works. |
| Workload (incl. contact hours, self-study hours) | Total workload: 50h<br>Contact hours:30h (18h lecture, 6h exercise, 6h lab)<br>Self-study:20h |
| Credit points | 2 ECTS |
| Required and recommended prerequisites for joining the module | MAT.1.1, MAT.1.2 |
| Module objectives/intended learning outcomes | In terms of Knowledge:<br>Soft computing is a set of so-called intelligent techniques that allow efficient control of automated systems and particularly autonomous mobile robots. The objective of this course is to present these techniques and make them accessible to students for implementation in practical cases.<br>Competencies: C2, C3, C5, C9 |
| Content | |

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| | Introduaction to Robotics and Soft computing (1.5 h)<br>Classical commands in robotics (3 h)<br>● Introduction and definitions<br>● Position control<br>● Speed control<br>● Position and speed control<br>● Limits of classical methods<br>III. Fuzzy control (10.5 h)<br>● Introduction and definitions<br>● Fuzzy logic operator<br>● Fuzzy rules<br>● Inference<br>● Fuzzy control process<br>IV. Neural control (9h)<br>● Introduction and definitions<br>● Deterministic Perceptron<br>● Probabilistic Perceptron<br>● Multi Layer Perceptron and error backpropagation<br>● Implementation of neural control<br>V. Path optimization (6h)<br>● Introduction and definitions<br>● Genetic algorithm<br>● Application in robotics |
| Examination forms | 100% Final exam |
| Study and examination requirements | 10/20 |
| Reading list | Dieulot, J.-Y., Dubois, L., Borne, P., & Rozinoer, J. (1998). Introduction à la commande floue. Editions Technip.<br><br>Faure, A. (2006). Classification et commande par réseaux de neurones. Editions Hermès.<br><br>Santhosh, S. (2012). Soft-I-Robot: Soft Computing Techniques. LAP Lambert Academic Publishing. |

# SEC.5.2 IoT Security

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| Module designation | SEC.5.2 IoT Security |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module | Mohamed Houcine Hdhili |
| Language | French |
| Relation to curriculum | Compulsory |
| Teaching methods | Lesson, Lab works |
| Workload (incl. contact hours, self-study hours) | Total workload:50h<br>Contact hours: 30h (18h lesson, 12h lab works)<br>Private study: 20h |
| Credit points | 2 ECTS |
| Required and recommended pre-requisites for joining the module | SEC.4.1 Cybersecurity and Cryptography<br>NET.4.1 Computer Networks |
| Module objectives/intended learning outcomes | Knowledge:<br>At the end of the course, the students will :<br>● Be able to discuss the main threats and attacks on IoT devices and services.<br>● Identify convenient cryptographic tools and protocols to secure devices, communications and IoT plateforms<br>● Be able to assess IoT threats and risks as they arise<br>● Be able to design a secure embedded system<br><br>Competencies: C6, C13 |

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| Content | Chapter 1 – IoT Security context<br>2. IoT security requirements<br>3. IoT security challenges<br>4. IoT potential risks in various use cases<br>5. IoT security risks assessments<br>Chapter 2 - Securing IoT devices<br>6. IoT device hardware and firmware<br>7. Vulnerabilities and Attacks at the Hardware Layer<br>8. Threat mitigation of the Hardware Layer<br>Chapter 3- Securing IoT network layer<br>9. IoT network layer vulnerabilities<br>10. Mitigating IoT network layer threats<br>Chapter 4 - Securing IoT application layer<br>11. IoT application layer vulnerabilities<br>12. OWASP projets (Secure coding, OWASP Top 10)<br>13. Mitigating IoT application layer threats<br>Chapter 5 – Securing IoT plateforms<br>14. Cloud security<br>15. Securing data at rest<br>Chapter 6 – Security in embedded systems<br>16. security risks in embedded systems<br>17. Mitigating embedded systems threats<br>18. STM32 security features<br><br>Lab Works:<br>Lab1: Firmware security assessments using OWASP-fstm.<br>Lab2: Testing commonly found vulnerabilities in IoT devices using the deliberately insecure firmware IoTGoat.<br>Lab3: audit IoT hardware security using HardSploit<br>Lab4: designing a secure embedded system, using the STM32Trust security framework. |
| Examination forms | 50% continuous assessment (lab works) + 50% written exam |
| Study and examination requirements | 10/20 |
| Reading list | 1- Hu, F. (2016). Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations. CRC Press.<br>2- Seshadri, N., & Dhakshinamoorthy, S. (2020). Internet of things (IoT) and Security. International Journal of Engineering Research & Technology (IJERT), NCAIT – 2020, 8(15).<br>3- IoTAA. (2016). IoTAA Security Guideline V1.2. Retrieved from https://www.iot.org.au/wp/wp-content/uploads/2016/12/IoTAA-Security-Guideline-V1.2.pdf<br>4- OWASP. OWASP Internet of Things Project. Retrieved from https://owasp.org/www-project-internet-of-things/<br>5- STMicroelectronics. STM32Trust. Retrieved from https://www.st.com/content/st_com/en/ecosystems/stm32trust.html |

## SEC.5.4 IoT security project

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| Module designation | SEC.5.4 IoT security Project |
| Semester(s) in which the module is taught | S5 |
| Person responsible for the module | Mohamed Houcine Hdhili |
| Language | French |
| Relation to curriculum | optional |
| Teaching methods | Project |
| Workload (incl. contact hours, self-study hours) | Total workload:25h<br>Contact hours : 15h (lab works)<br>Private study: 10h |
| Credit points | 1 ECTS |
| Required and recommended prerequisites for joining the module | SEC.4.1 Cybersecurity and Cryptography<br>NET.5. 2 Communication Architectures and protocols for IoT<br>SEC.5.1 IoT security |
| Module objectives/intended learning outcomes | Knowledge:<br>At the end of the course, the students will :<br>● Be able to identify security requirements for a specific IoT application<br>● Be able to design and implement a security solution for a specific IoT application<br>● Identify convenient cryptographic tools and protocols to secure IoT applications<br><br>Skills: Work with a team, manage time<br><br>Competencies: C6, C13 |
| Content | Project information:<br>- This is a project-based module. Students apply<br>- The instructor defines projects dealing with securing IoT applications (securing devices, embedded systems, network, and application layers)<br>- Students will be divided into groups.<br>- Each group chooses a project to develop ( requirements, design, implementation, and tests)<br>- Each group defines the project outline and divides the tasks among the team members.<br><br>Project samples:<br>- securing an e-health application<br>- securing a smart-home application<br>- securing a smart-hotel application |
| Examination forms | 100% project assessment |
| Study and examination requirements | 10/20 |

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| Reading list | Naoui, S., Elhdhili, M. E., & Azouz Saidane, L. (2020). Novel Enhanced LoRaWAN Framework for Smart Home Remote Control Security. Wireless Personal Communications, 110(4), 2109–2130.<br><br>Boussada, R., Balkis, H., Elhdhili, M. E., & Saidane, L. A. (2019). Privacy-preserving aware data transmission for IoT-based e-health. Computer Networks, 162.<br><br>Naoui, S., Elhdhili, M. E., & Saidane, L. A. (2019). Lightweight and Secure Password-Based Smart Home Authentication Protocol: LSP-SHAP. Journal of Network and Systems Management, 27(4), 1020–1042.<br><br>IoTAA Security Guideline V1.2. (2016). Retrieved from https://www.iot.org.au/wp/wp-content/uploads/2016/12/IoTAA-Security-Guideline-V1.2.pdf<br><br>https://owasp.org/www-project-internet-of-things/ |