Master's Degree
in
Computer Engineering for the Internet of Things

Student Information Booklet

Academic year 2020-2021

Approved by the Department Board of Ingegneria Informatica, Modellistica, Elettronica e Sistemistica on 23/04/2020.

Denominazione del Corso di Studio	**Ingegneria Informatica per l'Internet delle Cose**
Degree Course's Name	**Computer Engineering for the Internet of Things**
Academic year	**2020/2021**
Degree Course's class	**LM-32**
Department	**Department of Computer Engineering, Modeling, Electronics and Systems**
Coordinator/ representitiv of Degree Course	
Website	**www.dimes.unical.it**

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EDUCATIONAL OFFER – COHORT A.A.2020/2021

The Internet of Things (IoT) is a global, dynamic ecosystem with extensive and pervasive connectivity between conventional computing devices and next-generation everyday objects (Smart Objects). Smart Objects are a digital alias to real entities, enabling their entry into the IoT and thus gradually breaking down the boundary between the physical and virtual world.
In fact, we are witnessing a substantial paradigm shift, moving from an Internet designed exclusively for the human user, to an IoT centered on autonomous, intelligent, adaptive and interoperable cyber-physical devices, which simultaneously become suppliers and users of innovative services.
By synergistically exploiting technologies and methodologies from sectors such as Big Data, Cyberphysical Systems, Opportunistic Networking, Autonomic and Cognitive Computing, the IoT will revolutionize every application context.
The cyber-physical and multidisciplinary nature of the IoT requires highly qualified professionals with transversal knowledge for the development and management of such a heterogeneous and complex ecosystem.
The objective of the Master's Degree Course is the training of a new professional figure who can play, in innovative ICT companies, the roles of Embedded System Designer (a professional able to develop software for embedded systems used in IoT systems), IoT System designer (a professional able to develop innovative IoT systems as well as to integrate IoT systems, even heterogeneous ones in diversified application domains) and IoT data analytics specialist (a professional able to create solutions for the analysis of large amounts of data (Big Data) with particular reference to data produced by IoT systems.

Official study plan for full-time committed students.
The list of training activities offered.

Year	Semester	Teaching Unit	Type of Teaching Unit (TAF)	Field	Scientific Disciplinary Sector (SSD)	CFU
1	I	DISTRIBUTED SYSTEMS AND CLOUD/EDGE COMPUTING FOR IOT	Caratterizzante	Ingegneria informatica	ING-INF/05	**9**
		NETWORK ASPECTS OF THE INTERNET OF THINGS - MODULE 1: WIRELESS NETWORKING	Affine	Attività formative affini o integrative - A12	ING-INF/03	**6**
		BUSINESS MODELS OF IOT APPLICATIONS	Affine	Attività formative affini o integrative - A12	ING-IND/35	**6**
		SMART AGENTS AND SYSTEM ANALYSIS DESIGN AND IMPLEMENTATION	Caratterizzante	Ingegneria informatica	ING-INF/05	**9**
	II	BIG DATA MANAGEMENT	Caratterizzante	Ingegneria informatica	ING-INF/05	**6**
		ELECTRONICS FOR IOT DEVICES	Affine	Attività formative affini o integrative - A12	ING-INF/01	**6**
		NETWORK ASPECTS OF THE INTERNET OF THINGS - MODULE 2: COMMUNICATION PROTOCOLS FOR THE IOT	Affine	Attività formative affini o integrative - A12	ING-INF/03	**6**
		LOW LEVEL AND EMBEDDED SYSTEM PROGRAMMING	Caratterizzante	Ingegneria informatica	ING-INF/05	**9**
2	I	CONTROL TECHNIQUES FOR IOT SYSTEMS	Caratterizzante	Ingegneria informatica	ING-INF/04	**6**
		BIG DATA ANALYTICS	Caratterizzante	Ingegneria informatica	ING-INF/05	**6**
		IOT SYSTEMS - MODULE 1 - IOT PROGRAMMING	Caratterizzante	Ingegneria informatica	ING-INF/05	**6**
		IOT SECURITY	Caratterizzante	Ingegneria informatica	ING-INF/05	**6**
		Credits at Student's Choice	Altre attività	A scelta dello studente		**6**
	II	IOT SYSTEMS - MODULE 2 - IOT DEVELOPMENT METHODOLOGIES AND TOOLS	Caratterizzante	Ingegneria informatica	ING-INF/05	**6**
		Credits at Student's Choice	Altre attività	A scelta dello studente		**6**
		SEMINARS: SKILLS FOR THE FIRST ENTRY IN THE LABOUR MARKET	Altre attività	Ulteriori attività formative		**1**
		THESIS	Altre attività	Per la prova finale		**20**
Total CFU						**120**

Recommended courses of the student's choice						
Year	**Semester**	**Teaching Unit**	**Type of Teaching Unit (TAF)**	**Field**	**Scientific Disciplinary Sector (SSD)**	**CFU**
2		AGILE SOFTWARE DEVELOPMENT FOR ENTERPRISE (attivato dal Dipartimento di Matematica e Informatica, CdL magistrale in Informatica)	Altre attività	A scelta dello studente	INF/01	**6**
		PROCESS MINING (attivato dal Dipartimento di Matematica e Informatica, CdL magistrale in Informatica)	Altre attività	A scelta dello studente	INF/01	**6**
		SECURITY AND LEGAL ISSUES OF COMPUTER SCIENCE (attivato dal Dipartimento di Matematica e Informatica, CdL magistrale in Informatica)	Altre attività	A scelta dello studente	IUS/01	**6**
		SIGNALS AND SENSORS FOR IMAGE DIAGNOSTICS (mutuato dal modulo di Segnali e sensori elettromagnetici per la diagnostica ad immagini, magistrale di Ing. Telecomunicazioni)	Altre attività	A scelta dello studente	ING-INF/02	**6**

Those who do not present the study plan will be assigned one by the office.

For students who are not full-time engaged, the study plan will be agreed with the CdS.

Declarations of the individual training activities

Teaching Unit	Distributed Systems and Cloud/Edge Computing for IoT
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	9
Learning outcomes	-Knowledge of process communication aspects in distributed environments. -Knowledge of entity naming aspects. -Knowledge of the main synchronization techniques. -Knowledge of the main security aspects in distributed systems. -Knowledge of cloud computing models and systems. -Knowledge of edge computing models and systems. -Knowledge and use of cloud and edge computing technologies in the IoT.
Required prerequisites/ Prerequisities	None

Teaching Unit	Network aspects of the Internet Of Things
Scientific Disciplinary Sector (SSD)	ING-INF/03
Number of ECTS credits (CFU)	12
Learning outcomes	The educational objective of the "Network Aspects of the Internet of Things" course is to transfer to students the fundamental principles that underlie the network infrastructures and the related communication protocols for the Internet of Things, the knowledge of which is essential for a full understanding of the operation and for the design of advanced platforms for the exchange of information between devices of various kinds. - Knowledge and understanding: upon passing the exam, the student will know and understand the technological characteristics of the main wireless networks used for communication between IoT devices and objects, the protocols they use for managing access to the radio channel and for traffic routing in the case of distributed wireless networks, as well as the basic principles relating to the dynamic formation of network topologies and addressing.

	The student will also know the basic notions and technological features related to the main communication architectures, both traditional and innovative, designed for IoT devices and will have understood the operation of the main M2M communication protocols and the techniques used to virtualize IoT devices, for perform effective service discovery, and to ensure full interoperability between heterogeneous systems. - Ability to apply knowledge and understanding: upon passing the exam, the student is able to apply the theoretical knowledge acquired for the resolution of complex problems in the design of wired and wireless network environments specifically designed to support communications between IoT devices, including heterogeneous, and related protocols, using the most advanced technologies and methods available on the market. - Autonomy of judgment: upon passing the exam, the student is able to critically examine the results obtained in solving problems. The student will also be able to recognize situations in which to apply the acquired skills, to identify the type of problem and to independently evaluate possible alternatives for its resolution. - Communication skills: following the passing of the exam, the student is able to communicate the knowledge acquired through a technical-scientific language suitable for specialist and non-specialist interlocutors. - Learning skills: following the passing of the exam, the student is able to autonomously deepen the knowledge acquired and to apply it autonomously to the study of new topics to be addressed in the continuation of their study path and in the workplace.
Required prerequisites/ Prerequisities	None

Teaching Unit	Smart Agents and System Analysis Design and Implementation
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	9
Learning outcomes	-Abilities of abstracting the behavior of a concurrent and time dependent system through a formal model (Petri net or timed automata) and a thorough assessment of its properties. -Abilities to verifying the schedulability of simple real-time systems. -Abilities to exploiting the techniques of exhaustive model checking and/or of statistical model checking. -Abilities to making either a qualitative analysis and/or a quantitative analysis of an actor model using Uppaal. -Abilities to modelling and analyzing cyber-physical systems using actors. -Abilities to modelling, developing and analyzing the emergent properties of systems built in terms of the multi-agent paradigm.
Required prerequisites/ Prerequisities	Basic knowledge of computer engineering: Object oriented programming, Operating Systems, Software Engineering.

Teaching Unit	Big Data Management
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	6
Learning outcomes	-To know the fundamentals and the paradigms for designing and managing big data management architectures. -To know and be able to manage big data stores. -To know and be able to manage the main big data stream management systems.

Required prerequisites/ Prerequisities	The course requires the knowledge of data base systems, distributed systems and cloud services.

Teaching Unit	Electronics for IoT Devices
Scientific Disciplinary Sector (SSD)	ING-INF/01
Number of ECTS credits (CFU)	6
Learning outcomes	-Understanding of the operating principles of embedded systems. -Understanding of the methodologies for the analysis of digital systems realized as SoCs. -Ability to use the AXI protocol for exchanging data in embedded systems. -Ability to interface a general-purpose processor with custom modules in heterogeneous embedded systems. -Ability to use low-power design approaches.
Required prerequisites/ Prerequisities	Digital Electronics Hardware description language VHDL C and C++ languages

Teaching Unit	Business Models of IoT Applications
Scientific Disciplinary Sector (SSD)	ING-IND/35
Number of ECTS credits (CFU)	6
Learning outcomes	The course is aimed at learning techniques for business creation with particular reference to the so-called technological companies. Through the construction of a business plan of a company operating in the IoT sector, the main issues of a strategic, organizational and economic nature to be addressed for the development and management of a company are presented. Specific Skills: -Knowledge of the fundamental elements for the development of a strategic analysis (analysis of demand, competitors, operational context). -Knowledge of the fundamental elements for the preparation of a marketing plan. -Knowledge of the fundamental elements for drafting an organization plan for a new company. -Knowledge of the fundamental elements for the preparation of an economic-financial plan. Soft Skills: Ability to analyze and synthesize information in order to define corporate strategies. Ability to formulate judgments independently on one's own business situation and that of competitors. Team working skills, developed through the development of a business plan divided into small groups.
Required prerequisites/ Prerequisities	Knowledge of the general operating principles of an economic system (market economy, supply and demand) and a firm (basic principles of the economy and business organization, company balance sheet, main economic calculation methodologies for decision making).

Teaching Unit	Low level and Embedded System programming
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	9

Learning outcomes	Specific skills: -Knowledge of embedded devices architecture. -Knowledge of the problems of interfacing of embedded systems with the outside world. -Skills in programming of embedded devices based on diverse types of microcontrollers. -Skills and expertise of microcontroller interfacing with electronic components and external devices. Transversal skills: -Skill in solving complex problems. -Skills in collaboration and cooperation in groups and in the illustration of common work.
Required prerequisites/ Prerequisities	Basics of computer programming. Basics of electronics.

Teaching Unit	Control Techniques for IoT Systems
Scientific Disciplinary Sector (SSD)	ING-INF/04
Number of ECTS credits (CFU)	6
Learning outcomes	The student will be able to analyze the behavior of networked control systems and design simple control algorithms, in particular distributed control methods for large-scale dynamical systems.
Required prerequisites/ Prerequisities	Linear Algebra, Calculus, Feedback Control basics.

Teaching Unit	Big Data Analytics
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	6
Learning outcomes	This course aims to provide students with advanced knowledge on computational problems and related solutions for the analysis of large amounts of data and data streams in applications based on distributed systems, through the use of methodologies, methods and techniques of Knowledge Discovery, Data Mining, and Machine / Deep Learning. Furthermore, students will gain knowledge on the use of technologies for Big Data Analytics, including frameworks, development environments and software libraries, with particular attention to Apache Spark and its Streaming and MLlib components, as well as Apache Kafka. Specific skills: -Understanding the main models, methods, algorithms for data preparation and modeling, data analysis and knowledge extraction through supervised and unsupervised learning. -Understanding computational problems, also of multidisciplinary interest, and applications in Big Data fields.
Required prerequisites/ Prerequisities	Big Data Management course delivered at the first year of the same laurea programme.

Teaching Unit	IoT Systems
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	12
Learning outcomes	Students will acquire knowledge and skills which are both theoretical/methodological and practical; in particular, students will acquire

	both knowledge about the main methods and algorithms for programming IoT systems and for their design, and the practical skills allowing them to concretely use operating systems, specific languages, methodologies and tools to develop software components for such systems.
Required prerequisites/ Prerequisities	None

Teaching Unit	IoT Security
Scientific Disciplinary Sector (SSD)	ING-INF/05
Number of ECTS credits (CFU)	6
Learning outcomes	Knowledge and understanding: Students are expected to acquire knowledge of both a theoretical/methodological and practical nature. Specifically, students will gain knowledge on the following innovative topics: (i) security for specific IoT devices, involving hardware exposure (cyberphysical security) and need for lightweight and flexible solutions based on cryptographic algorithms, anti-malware, IDS and firewalls; (ii) cross-layer security across IoT systems (from perceptual to application) involving Trust Management systems capable of autonomously ensuring trusted social relationships between unknown entities (people, devices or services), lightweight authentication mechanisms coupled with digital identity management across entities, and data protection (privacy) mechanisms where the user can also transparently apply their preferences; (iii) Blockchain technology. Ability to apply knowledge and understanding: The objective of the course is to give the fundamentals and some tools for the design and implementation of a secure IoT system. Autonomy of judgment: Ability to understand and identify advantages and limitations of applicability of cybersecurity methodologies and technologies. Communication Skills: Ability to explain, including relying on practical examples, key cybersecurity issues and their solutions. Learning skills: Ability to address at a professional level the issues of computer security and to independently update the specific skills acquired.
Required prerequisites/ Prerequisities	Good knowledge of a high level programming language such as C / C ++ or Java. Good knowledge of the principles of distributed systems and computer networks.

Teaching Unit	Seminars: skills for the first entry in the labour market
Scientific Disciplinary Sector (SSD)	
Number of ECTS credits (CFU)	1
Learning outcomes	After completing this course the students will: - have deep understanding about the personal abilities that are most required for computer engineers by Industry and Public Administration - achieve knowledge about the labour market and hiring selection methods.
Required prerequisites/ Prerequisities	None

Competence mapping

Learning outcomes	Teaching Unit
Knowledge of technologies and tools for the design and maintenance of centralized and distributed processing systems, with particular reference to IoT systems.	Distributed Systems and Cloud/Edge Computing for IoT Smart Agents and System Analysis Design and Implementation
Ability to understand the evolutions underway in the organization of hardware-software architectures to respond more effectively to the increasingly extensive requirements of IoT services.	Big Data Management IoT Systems
Knowledge of technologies and software development environments with extensive use of the potential of agent systems, and ability to understand the basic methodological principles that characterize the new trends in software engineering, with particular reference to IoT systems.	Smart Agents and System Analysis Design and Implementation IoT Systems
Knowledge of technologies, languages and software development environments useful for programming embedded systems and device drivers, used in the context of IoT systems.	Low level and Embedded System programming
Knowledge of technologies, tools and components for the management of massive (Big Data) and heterogeneous (NoSQL) databases; ability to understand the evolution of database technologies to allow the management of ever larger data warehouses and in streaming data contexts that characterize IoT systems.	Big Data Management
Knowledge of data analysis techniques for the development of solutions for the extraction, management and sharing of knowledge in the IoT field.	Big Data Analytics
Knowledge of control and automation techniques with specific reference to IoT systems.	Control Techniques for IoT Systems
Knowledge of digital electronics with particular reference to programmable devices used in IoT systems.	Electronics for IoT Devices
Knowledge of telecommunications and in particular of wireless networks and communication protocols used by IoT devices.	Network aspects of the Internet Of Things

Knowledge of IT security techniques and skills for their applications for the protection of IoT systems.	IoT Security
Knowledge of economic-management engineering with particular reference to the business models of innovative ICT companies.	Business Models of IoT Applications

Learning outcomes	**Teaching Unit**
Ability to understand, analyze and formalize problems related to the automation of services in public and private entities using modern technologies based on IoT.	Distributed Systems and Cloud/Edge Computing for IoT Smart Agents and System Analysis Design and Implementation IoT Systems IoT Security Control Techniques for IoT Systems Business Models of IoT Applications Network aspects of the Internet Of Things
Ability to understand, analyze and formalize problems inherent in the development of solutions for data analysis, with particular reference to the analysis of heterogeneous data flows such as those typically produced in IoT systems.	Big Data Management Big Data Analytics Business Models of IoT Applications
Ability to understand, analyze and formalize problems inherent in the control of production processes and complex systems achieved through IoT systems.	Distributed Systems and Cloud/Edge Computing for IoT Smart Agents and System Analysis Design and Implementation IoT Systems IoT Security Control Techniques for IoT Systems Network aspects of the Internet Of Things

Ability to understand, analyze and formalize problems related to the development of software components for automation and home automation.	Low level and Embedded System programming Control Techniques for IoT Systems Electronics for IoT Devices