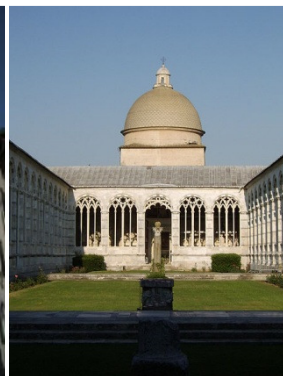


Graduate Program in Information Science and Technology



Courses and Exams

The Master of Science in Computer Science is aimed at training professionals provided with both an in-depth understanding of the theoretical principles of computer science, and a specific collection of knowledge related to one of the following areas:

- The area *Software technologies* provided students with the knowledge required to deal with the analysis, the design and the development of large-scale software systems, with a particular emphasis on properties such as quality, correctness and security.
- The area *Systems and networks* provides students with the ability of designing and understanding large systems composed of a distributed collection of interacting entities. Examples include both technological systems such as distributed systems and networks, as well as complex relational systems such as social networks.
- The area *Data media and knowledge* provides students with the knowledge required to extract, manage and present information, with courses related to machine learning, advanced information systems and the web.
- The area *Embedded systems and ambient intelligence* is focused on the methodologies for the development of software applications for embedded systems, one of the fastest growing areas in ICT. Applications range from automatic controls used in industrial, automotive and avionic systems, to recent infotainment systems (e.g. smart phones), to domotics and ambiente intelligence.

Students complete their 2 year studies by **132** credits, **66** credits taken each year. The courses include *mandatory courses* that must be taken by the student regardless his choice; *elective courses* that can be chosen from the list proposed; *free choice courses* that give the student a chance to choose the course according to his likes and field of interest, including courses offered by any of Faculties of the University of Trento.


The degree is completed with 6 credits for the stage activity and 18 credits for the final thesis.


Data, Media & Knowledge

The specialization has a number of compulsory courses aiming to teach students about the Web, the Information Systems, and many important foundations of Computer Science. Furthermore, it trains students in two areas that are becoming critical for the design of the future innovative systems: automated reasoning and knowledge extraction. The specialization includes an additional number of optional courses that complement the communicated knowledge with topics about Speech Recognition, Video Processing, Computer Graphics and Semantic Web.

Students complete their studies by 30 credits as free-choice. An additional collection of eligible courses for the Data, Media & Knowledge specialization is suggested here; other courses may be selected from the complete list of courses.

DMK Profile 1

 Courses taken in Pisa

 Courses taken in Trento

1st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		48
Concurrent Programming	ING/INF05	6
Real-time systems	ING/INF05	6
Object Oriented Software Design	ING/INF05	12
3D Graphics for Virtual Reality	ING/INF05	6
Security	ING/INF05	6
Optimization methods for IT	MAT/09	6
Probability and Statistics In Computer Science	MAT/06	6
Elective courses		18
Interaction with Virtual Environments	ING/INF05	6
Laboratory of embedded systems	ING-INF/05	6
Model Based Techniques for Software Development	ING/INF05	12
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		24
Advanced Information Systems	ING/INF 05	6
Data Mining for Knowledge Management	ING/INF 05	6
Computability	MAT01	6
Computational complexity	INF01	6
Elective courses		18
Web Architectures	INF01	6
Concurrency theory	INF01	6
Network Security	ING/INF05	6
Agent-oriented Software Engineering	ING/INF05	6
Real Time operating systems and middleware	ING/INF05	6
Advanced Networking	ING/INF05	6
Logics for Data and Knowledge Representation	ING/INF05	6
Thesis		18
Stage (Optional)		6

DMK Profile 2

1st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		48
Concurrency theory	INF01	6
Real-time Operating Systems	ING/INF05	6
Web languages	INF01	12
Organizational Information Systems	ING/INF05	6
Logics for Data and Knowledge Representation	ING/INF05	6
Computability	MAT01	6
Computational complexity	INF01	6
Elective courses		18
Agent-oriented software engineering	ING/INF05	6
Web Architectures	INF01	6
Signals and Systems	ING/INF05	12
Data Mining for Knowledge Management	INF01	6
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		24
Object Oriented Software Design	ING/INF05	12
Optimization methods for IT	MAT09	6
Probability and Statistics In Computer Science	MAT06	6
Elective courses		18
Concurrent Programming	ING/INF05	6
Security	ING/INF05	6
Real-time systems	ING/INF05	6
Model Based Techniques fo Software Development	ING/INF05	12
3D Graphics for Virtual Reality	ING/INF05	6
Interaction with Virtual Environments	ING/INF05	6
Concurrent Programming	ING/INF05	6
Thesis		18
Stage (Optional)		6


Systems & Networks


The System and networks specialization is aimed at educating professionals capable to dominate the inherent complexity of future networks, designing and managing the interconnected systems of the future society. The portfolio of offered courses covers all aspects of the distributed systems area, from low-level communication protocols to high-level applications and services, including also theoretical courses where the general problem of analyzing, managing and organizing large-scale, complex systems is discussed. Students are free to create their preferred mixture of courses by carefully preparing their study plan.

Possible suggestions for study plans are as follows:

- A study plan more oriented towards distributed systems, web, and complex systems: Machine Learning, Web Mining, Performance Evaluation, Distributed Systems, Complex Systems, Web architectures, Organizational Information Systems.
- A study plan more oriented towards networking: Advanced networking, Nomadic communications, Performance evaluation, System security, Network security, Distributed systems, Web architectures.

System and Networks. Profile 1

 Courses taken in Pisa

 Courses taken in Trento

1 st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		42
Concurrent Programming	INF01	6
Real-time systems	ING/INF05	6
Object Oriented Software Design	ING/INF05	12
Model Based Software Development	ING/INF05	12
Optimization methods for IT	MAT09	6
Elective courses		6-12
Probability and Statistics in Computer Science	Math06	6
Mathematical Methods for network optimization	MAT09	6
Laboratory of embedded systems	ING/INF05	6
3D Graphics and virtual reality	ING/INF05	6
Security	ING/INF05	6
Free Choice Courses		18
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		24
Computability	MAT01	6
Computational complexity	INF01	6
Web Architectures	INF01	6
Advanced Networking	ING-INF05	6
Elective courses		0-6
Nomadic communication	ING/INF05	6
Network Security	ING/INF05	6
Distributed Systems	INF01	6
Machine Learning	INF/01	6
Computer Security	ING/INF05	6
Performance Evaluation	ING/INF05	6
Wireless Sensor Networks	ING/INF05	6
Web Mining	INF/01	6
Mathematical Logic	INF01	6
Concurrency theory	INF01	6
Machine Learning	INF01	6
Free Choice Courses		12
Thesis		18
Stage (Mandatory)		6

Systems and Networks. Profile 2

1 st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		42
Concurrency theory	INF01	6
Web Architectures	INF01	6
Advanced Networking	ING/INF05	6
Computability	MAT01	6
Computational complexity	INF01	6
Machine Learning	INF01	6
Nomadic Communications	ING/INF05	6
Elective courses		6-12
Mathematical Logic	MAT01	6
Wireless Sensor Networks	ING/INF05	6
Web Mining	INF/01	6
Network Security	ING/INF05	6
Distributed Systems	INF01	6
Computer Security	ING/INF05	6
Free Choice Courses		18
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		30
Object Oriented Software Design	ING/INF05	12
Optimization methods for IT	mat09	6
Real-time systems	ING/INF05	6
Laboratory of embedded systems	ING/INF05	6
Elective courses		0-6
Concurrent Programming	ING/INF05	6
Security	ING/INF05	6
Probability and Statistics in Computer Science	MAT06	6
Mathematical Methods for network optimization	mat09	6
3D Graphics and virtual reality	ING/INF05	6
Model Based Techniques for Software Design	ING/INF05	12
Free Choice Courses		12
Thesis		18
Stage (Mandatory)		6

Software Technologies


This curriculum address the challenges of the analysis, design and software development of large scale socio-technical systems with proven quality of assurance, correctness, security and usability. The curriculum can be essentially designed in three main stream


- **Design:** the courses part of this stream complements the traditional part of Software Engineering in BSc courses with the analysis of organizational requirements behind the development of software systems (Requirements Engineering) and new development methodologies (Agent-Oriented Software Engineering) and usability (Human Computer Interaction).
- **Assurance and Security:** here the courses focus on the analysis of trust and security at organizational and business process level (Computer Security) and lower level (Network Security) that are . Also in this case usability considerations (Human-Computer Interaction) play a key role.
- **Correctness:** this stream faces the challenges of the design of a correct software systems through the technology of testing (Software Analysis and Testing, and Laboratory of Software Analysis) and the complementary techniques of formal verification and model checking (Formal Methods).

The curriculum can be complemented with a number of courses from other curricula among the suggested alternatives students can explore the issue behind the design of Organizational Systems where socio-technical issues are considered more thoroughly. Further we have envisaged the aspects of Software Management, for students that intends to continue their careers in Industry, and Research Projects in Software Technologies, for students interested in deepening their knowledge of applied research topics.

Students interested to pursue specialization in the areas of Design, Assurance and Correctness are also encouraged to take the advanced 3credits courses in each of the above area that are offered in the framework of the PhD program (Conceptual Modeling and Ontological Analysis, Access Control and Information Theory, Advanced Software Verification).

Software Technologies. Profile 1

 Courses taken in Pisa

 Courses taken in Trento

1 st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		48
Concurrent Programming	INF/01	6
Real-time systems	ING-INF/05	6
Object Oriented Software Design	ING-INF/05	12
Model Based Software Development	ING-INF/05	12
Optimization methods for IT	MAT/09	6
Elective courses		6-12
Security	ING-INF/05	6
Laboratory of embedded systems	ING-INF/05	6
3D Graphics and virtual reality	ING-INF/05	6
Interaction with Virtual Environments	ING/INF05	6
Probability and Statistics In Computer Science	MAT/06	6
Free Choice Courses		12-18
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		24
Requirements Engineering	ING-INF/05	6
Computer Security	ING/INF/05	6
Computational complexity	INF/01	6
Computability	MAT/01	6
Elective courses		0-6
Nomadic communication	ING-INF/05	6
Formal Methods	INF/01	12
Real-time Operating Systems	ING-INF/05	6
Concurrency Theory	INF/01	6
Automatic Control	ING-INF/04	6
Software analysis and testing	ING/INF05	
WSN	ING-INF/05	6
Advanced Architectures	ING-INF/01	6
Research Project in Software Technologies	ING-INF/05	12
Free Choice Courses		12
Thesis		18
Stage (Mandatory)		6

Software Technologies. Profile 2

1st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		48
Concurrency theory	INF 01	6
Real-time Operating Systems	ING-INF/05	6
Requirements Engineering	ING-INF/05	6
Computer Security	ING-INF/05	6
Formal Methods	INF/01	12
Computability	MAT/01	6
Computational complexity	INF/01	6
Elective courses		6-12
Nomadic Communication	ING-INF/05	6
Automatic Control	ING-INF/04	6
WSN	ING-INF/05	6
Advanced Architectures	ING-INF/01	6
Research Projects in Embedded systems	ING-INF/05	12
Free Choice Courses		6-12
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		18
Object Oriented Software Design	ING-INF/05	12
Optimization methods for IT	MAT/09	6
Elective courses		0-6
Laboratory of embedded systems	ING-INF/05	6
Model Based Techniques for Software Development	ING-INF/05	12
Probability and Statistics In Computer Science	MAT/06	6
Real-time systems	ING-INF/05	6
Concurrent Programming	ING-INF/05	6
3D Graphics and virtual reality	ING-INF/05	6
Interaction with Virtual Environments	ING/INF05	6
Security	ING-INF/05	6
Free Choice Courses		18
Thesis		18
Stage (Mandatory)		6

Embedded Systems and Ambient Intelligence


Electronic technology has become the mainstay of any engineering system with complex functionality. Automobiles, air-planes, even everyday use objects such as pens and domestic appliances have an important electronic dimension, which is typically transparent to the users. For this reason, the electronic devices immersed in larger systems are called embedded systems. Among the most important functions embedded systems enable are control and monitoring of the operation of mechanical systems such as automotive engines or suspensions, chemical systems such as distillation towers, and communication systems such as cellular phones. The pervasiveness of these components is well illustrated by the following examples:


- the European automotive sector has a turnover of around 500 Billions Euro and it employs 2.7 million people in the EU. As of today, the 20% of the value of each car is due to embedded electronics. This ratio is expected to increase to 35-40% by 2015 creating more than 600.000 jobs in the automotive embedded systems alone (source ARTEMIS initiative)
- in the year 2005 the total amount of money spent in the EU for R&D activities in the Embedded systems areas is estimated in 20.000 millions Euro (19.750 from private investment and 250 from public investments). It is expected that in 2010 the total expenditure will overcome 28500 Millions Euro.

The development of EC is a very complex activity for a variety of reasons. The first problem is the presence of tight safety requirements. A failure of the system can even result in the loss of human lives. Moreover, fixing a problem in a system shipped in thousands of units can result in enormous additional costs for its manufacturer. Other issues such as time-to-market, cost of the deployed architecture, power consumption and memory footprint are also known to play a role of increasing importance. In short, designers and engineers are confronted with a challenge of overwhelming complexity: reliable (and often safety-critical) applications have to be developed in a short time using low-cost components. In order to cope with these challenging issues, an engineer operating in this domain must be provided with a wide body of knowledge, spanning over diverse scientific and technological disciplines. To build this knowledge, the faculty proposes a curriculum consisting of mandatory and optional courses. The mandatory courses cover the following cultural domains:

- Hardware/software platforms: the developer of embedded software has cost containment among his/her primary concerns. Hence, he/she needs foundational information on the main trade-offs present in hardware design and on how real-time computations can be performed even on low cost platforms. This information is conveyed by “advanced architectures” and “real-time operating systems”.
- Production of safety critical code: the correctness of the produced code is really the name of the game. Basic methodological skills on functional and temporal correctness will be offered in the “formal methods” and in the “real-time operating systems” courses.
- Networking: tomorrows embedded systems will be networked to an unprecedented extent. Particularly, wireless networking will take the lion share. Advanced information on wireless networking will be offered in the “nomadic communications” course
- Signal and Systems: most embedded systems are used to process signals and implement control systems. A basic knowledge on this wide discipline will be offered in the Signal and Systems course.

Embedded Systems. Profile 1

 Courses taken in Pisa

 Courses taken in Trento

1 st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		42
Concurrent Programming	ING/INF05	6
Real-time systems	ING/INF05	6
Object Oriented Software Design	ING/INF05	12
Model Based Software Development	ING/INF05	12
Optimization methods for IT	ING/INF05	6
Elective courses		6-12
Security	ING-INF/05	6
Laboratory of embedded systems	ING-INF/05	6
3D Graphics and virtual reality	ING-INF/05	6
Interaction with Virtual Environments	ING/INF05	6
Probability and Statistics In Computer Science	MAT/06	6
Free Choice Courses		18
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		24
Signals and systems	ING-INF/05	6
Laboratory of Embedded Control Systems	ING/INF/05	6
Computational complexity	INF/01	6
Computability	MAT/01	6
Elective courses		0-6
Nomadic communication	ING-INF/05	6
Formal Methods	INF/01	12
Real-time Operating Systems	ING-INF/05	6
Concurrency Theory	INF/01	6
Automatic Control	ING-INF/04	6
Research Project in Embedded systems	ING-INF/05	12
WSN	ING-INF/01	6
Advanced Architectures	ING-INF/05	6
Free Choice Courses		12
Thesis		18
Stage (Mandatory)		6

Embedded Systems. Profile 2

1st year (66 credits)		
Course	Sector	Credits
Mandatory Courses		48
Concurrency theory	INF 01	6
Real-time Operating Systems	ING-INF/05	6
Signal and systems	ING-INF/05	6
Laboratory of Embedded Control Systems	ING-INF/05	6
Formal Methods	INF/01	12
Computability	MAT/01	6
Computational complexity	INF/01	6
Elective courses		6-12
Nomadic Communication	ING-INF/05	6
Automatic Control	ING-INF/04	6
WSN	ING-INF/05	6
Advanced Architectures	ING-INF/01	6
Research Projects in Embedded systems	ING-INF/05	12
Free Choice Courses		6-12
2nd year (66 credits)		
Course	Sector	Credits
Mandatory Courses		18
Object Oriented Software Design	ING-INF/05	12
Optimization methods for IT	ING-INF/05	6
Elective courses		6
Laboratory of embedded systems	ING-INF/05	6
Model Based Techniques for Software Development	ING-INF/05	12
Probability and Statistics In Computer Science	MAT/06	6
Real-time systems	ING-INF/05	6
Concurrent Programming	ING-INF/05	6
3D Graphics and virtual reality	ING-INF/05	6
Interaction with Virtual Environments	ING-INF/05	6
Security	ING-INF/05	6
Free Choice Courses		18
Thesis		18
Stage (Mandatory)		6

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