

MSc on Applied Computer Science

(Majors in *Security* and *Computational Biology*)

Amílcar Sernadas, Ana Teresa Freitas, Arlindo Oliveira, Isabel Sá Correia

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1 Context

The new model for high education that has been adopted by IST, following the Bologna declaration, should aim not only at preserving the high standards that are common to existing degrees, but also at creating new opportunities for student mobility and lifelong education.

In this context, the second cycles leading to the MSc degree play an important role. They should complement the education in basic sciences that is a hallmark of the first cycles, but, additionally, give students a wider choice of possibilities of education than the ones available when they enter IST.

This document is a draft of a proposal for a second cycle in applied computer science that, in the spirit of the Bologna declaration, is accessible to students with a wide range of backgrounds.

1.1 Objectives and targets

The degree in applied computer science is targeted at students that, originating from a diverse set of educational backgrounds, have interest in applied computing. Two major application areas have been identified, and are included in the present proposal: computational biology and security. Both represent strategic areas of high potential impact, that are likely to continue to grow in importance in the next decades. Investing in these areas is strategic for the future development of science and technology in Europe. Portugal and IST should not ignore this challenge.

Computational biology and security require extensive familiarity with computer science and discrete mathematics and share many other common requirements. By teaching the majority of the courses in English, and by directly marketing this degree at specific universities and research groups in other countries, we expect to be able to attract a significant number of foreign students.

The degree includes a bridging component in order to make it accessible to students with education in engineering, informatics, math, physics, chemistry, or biology. Depending on their familiarity with the topics of these courses, students will take up to 4 topics considered fundamental for the degree.

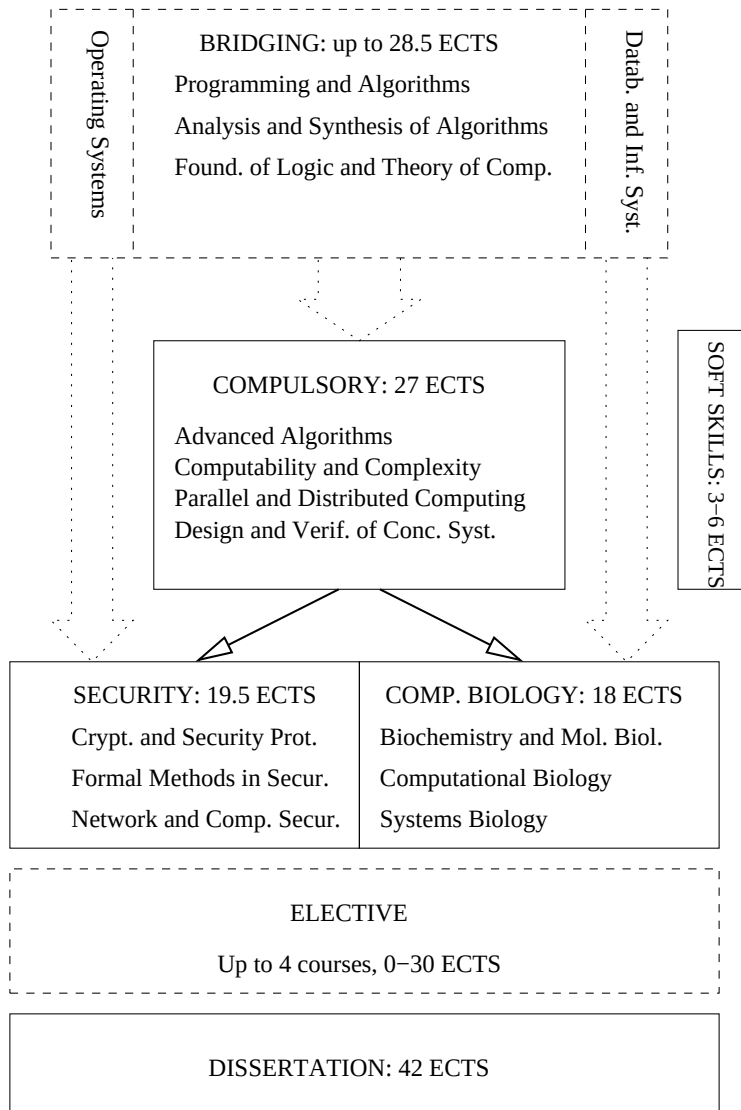
Given the limitations imposed by the wide variety of backgrounds, and the need to acquire a number of specific skills, limited emphasis will be put on the component of software engineering. In particular, little superposition exists with the IST degree in Information and Software Engineering, targeted at engineering professionals that will center their activity on the development of complex software systems. Furthermore, very little superposition exists also with the IST degree in Applied Mathematics where discrete mathematics plays a very small role.

Graduating students will have a number of options for employment in high-tech companies, research laboratories and universities. Some will immediately apply their knowledge and skills in Portuguese and European companies with specific requisites in growing or emerging areas of computer science such as bioinformatics, security, privacy and quantum computing. Others will first pursue doctoral degrees in these or related areas.

2 Structure of the degree

This curriculum is organized in four major blocks of disciplines:

- Bridging courses: required for students to gain the necessary background in Computer Science or for the selected major.
- Compulsory courses: constitute the core of the curriculum, and provide a solid education in advanced computer science topics.
- Specialization courses: are chosen in accordance with the selected major and provide in-depth education in the specific field.
- Elective courses: add flexibility to the curriculum, and can be chosen to adapt to the interests of individual students.



3 Detailed description of the degree

The students should take 120 ECTS as follows:

3.1 Bridging courses (up to 4 courses)

Depending on the previous background each student will be enrolled by the Coordinators in up to four of the following courses:

- Analysis and Synthesis of Algorithms
(Análise e Síntese de Algoritmos) [DEI,SEM2,7.5ECTS];
- Programming and Algorithms
(Programação e Algoritmos) [DM,SEM1,6.0ECTS];
- Foundations of Logic and Theory of Computing
(Fundamentos de Lógica e Teoria da Computação) [DM,SEM1,7.5ECTS];
- Databases and Information Systems (*students in Computational Biology*)
(Sistemas de Informação e Bases de Dados) [DEI,SEM1,7.5ECTS];
- Operating Systems (*students in Security*)
(Sistemas Operativos) [DEI,SEM1,6.0ECTS].

The remaining slots are used for elective courses (see below).

3.2 Compulsory courses (4 courses)

- Advanced Algorithms
(Tópicos Avançados em Algoritmos) [DEI,SEM2,7.5ECTS];
- Computability and Complexity
(Computabilidade e Complexidade) [DM,SEM1,6.0ECTS];
- Parallel and Distributed Computing
(Computação Paralela e Distribuída) [DEI,SEM2,7.5ECTS];
- Design and Verification of Concurrent Systems
(Concepção e Verificação de Sistemas Concorrentes) [DM,SEM2,6.0ECTS].

3.3 Specialization courses (3 courses)

The students choose either to major in Computational Biology:

- Biochemistry and Molecular Biology
(Bioquímica e Biologia Molecular) [DEQB,SEM1,6.0ECTS];
- Systems Biology
(Biologia de Sistemas) [DEQB/DEI/DEEC,SEM1,6.0ECTS];
- Computational Biology
(Biologia Computacional) [DEI/DEEC/DEQB,SEM1,6.0ECTS];

or to major in Security:

- Cryptography and Security Protocols
(Criptografia e Protocolos de Segurança) [DM,SEM2,6.0ECTS].
- Formal Methods in Security
(Métodos Formais em Segurança) [DM,SEM1,6.0ECTS];
- Network and Computer Security
(Segurança Informática em Redes e Sistemas) [DEI,SEM1,7.5ECTS].

3.4 Dissertation

The students should prepare an original dissertation in the area of the selected major. The dissertation involves an estimated effort of 42 ECTS.

3.5 Soft skills

The students should take between 3 and 6 ECTS in courses aimed at improving the soft skills, named *Seminars in Computer Science*. In these seminars, the students will follow a work-plan defined by the course coordinator, that may include seminars, oral presentations, independent studies and journal clubs. Additionally, we consider that 3 ECTS of the 42 allocated to the thesis will correspond to soft skills, since a significant part of the effort required to write the dissertation is related with non-technical material.

3.6 Elective courses (up to 4 courses)

The total number of elective and bridging courses must be 4. For the remaining slots, the students can choose courses from the other specialization area plus:

- Databases and Information Systems
(Sistemas de Informação e Bases de Dados) [DEI,SEM2,6.0ECTS];
- Operating Systems
(Sistemas Operativos) [DEI,SEM1,6.0ECTS].
- Quantum Computation and Information
(Computação e Informação Quânticas) [DM,SEM2,6.0ECTS];
- Machine Learning
(Aprendizagem Automática) [DEEC,SEM1,6.0ECTS];
- Optimization and Algorithms
(Optimização e Algoritmos) [DEEC,SEM1,6.0ECTS];
- Algebraic Structures in Computer Science
(Fundamentos Algébricos da Computação) [DM,SEM2,6.0ECTS];
- Management and Treatment of Information
(Gestão e Tratamento de Informação) [DEI,SEM1,7.5ECTS]

- Functional Logic and Proof Theory
(Lógica Funcional e Teoria da Demonstração) [DM,SEM2,6.0ECTS];
- Computational Logic
(Lógica Computacional) [DM,SEM2,6.0ECTS];
- Statistical Genomics
(Genómica Estatística) [DM,SEM2,6.0ECTS];
- Genetic Engineering
(Engenharia Genética) [DEQB,SEM1,6.0ECTS];
- Functional Genomics and Bioinformatics
(Genómica Funcional e Bioinformática) [DEQB/DEI/DEEC,SEM2,6.0ECTS];
- Distributed Systems
(Sistemas Distribuídos) [DEI,SEM2,7.5ECTS];

4 Scientific areas

The courses are classified into the following scientific areas (courses already offered to students of other degrees are marked with (*)):

4.1 Logic and Computation

- Programming and Algorithms [bridge]
- Foundations of Logic and Theory of Computing [bridge] (*);
- Theory of Complexity [compulsory] (*);
- Design and Verification of Concurrent Systems [compulsory] (*);
- Cryptography and Security Protocols [compulsory for Security] (*);
- Formal Methods in Security [compulsory for Security] (*);
- Quantum Computation and Information [elective] (*);
- Algebraic Structures in Computer Science [elective] (*);
- Functional Logic and Proof Theory [elective] (*);
- Computational Logic [elective] (*).

4.2 Algorithmics

- Analysis and Synthesis of Algorithms [bridge] (*);
- Advanced Algorithms [compulsory] (*);
- Parallel and Distributed Computing [compulsory] (*);
- Computational Biology [compulsory for Computational Biology] (*);

4.3 Biological Sciences

- Biochemistry and Molecular Biology [compulsory for Computational Biology] (*);
- Functional Genomics and Bioinformatics [elective] (*);
- Genetic Engineering [elective] (*).
- Systems Biology [compulsory for Computational Biology] (*).

4.4 Information Systems

- Databases and Information Systems [bridge for Computational Biology] (*);
- Management and Treatment of Information [elective] (*).

4.5 Decision and Control

- Machine Learning [elective] (*);
- Optimization and Algorithms [elective] (*).

4.6 Computer Architectures and Operating Systems

- Operating Systems [bridge for Security] (*)
- Network and Computer Security [compulsory for Security] (*).
- Distributed Systems [elective] (*)

4.7 Statistics

- Statistical Genomics [elective].

5 Numerus clausus

Initially, it is envisaged to accept up to 25 students each year, selecting the top candidates from Portugal and abroad with relevant education, namely in engineering, informatics, math, physics, chemistry, or biology.

6 Coordination

Joint coordination by DEI and DM. Scientific Council appointed by DEEC (1), DEI (2), DEQB (1) and DM (2).