

# **Master's Programme in Computer, Communication and Information Sciences Study Guide 2016-2017**

## **For the reader**

This study guide explains the degree requirements of the programmes, and gives students the necessary information about completing the degree and its contents.

In addition to study guides, Aalto University uses various online services for planning and monitoring one's studies, and for keeping up with what is going on at the university. In planning one's studies, this study guide and the online tools complement each other and should be used side by side.

Below is an introduction to students' most important online tools:

## *WebOodi*

Course descriptions,  
registering for courses and exams,  
planning your studies  
(personal study plan)

## *Study guide*

Degree structure and the courses  
it consists of

## *MyCourses*

Course home pages, timetables,  
materials, course spaces,  
course news

## *Into*

is a student portal, with information about studies,  
Aalto services and Aalto university in general.

The Into pages give you general information about studies: timetables, instructions on registration, advice on how to plan your studies and draw up a personal study plan, forms, information about studies abroad or in other Aalto schools or other Finnish universities, common practices in courses, academic rules and regulations etc. Into pages of the programme: [into.aalto.fi/display/enccis/](https://into.aalto.fi/display/enccis/).

## **Degree structure**

**Directors of degree programme:** Professor Petri Vuorimaa (SCI), Professor Riku Jäntti (ELEC)

**Degree:** Master of Science (Technology), 120 ECTS

**Abbreviation:** CCIS

Master of Science (Technology) degree is 120 ECTS credits. The degree consists of major studies, master's thesis and elective studies. Some majors offer both long and compact options. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

## **Objectives**

Master's Programme in Computer, Communication and Information Sciences (CCIS) is jointly organized by the School of Electrical Engineering and the School of Science. The CCIS programme's core courses provide strong foundation in computer science, communication engineering, and information science. In addition, students can immerse themselves deep into one of the specialization tracks or focused majors.

In CCIS, education is based both on scientific research and industrial state-of-the-art. Students gain in-depth knowledge in one major. They learn how to apply scientific knowledge and scientific methods independently. Students interested in pursuing doctoral studies after their M.Sc. degree can easily transfer to the Helsinki Doctoral Education Network in Information and Communications Technology (HICT). Students acquire professional language and communication skills. All students are encouraged to include international, multidisciplinary, and entrepreneurial components as part of their studies.

### **Long major:**

**MAJOR  
55-65 ECTS**

**MASTER'S THESIS  
30 ECTS**

**ELECTIVE STUDIES  
25-35 ECTS**

**Compact major:**

**MAJOR  
40-45 ECTS**

**MASTER'S THESIS  
30 ECTS**

**MINOR  
20-25 ECTS**

**ELECTIVE STUDIES  
25-35 ECTS**

## **Elective studies**

Students choose 25-35 credits of elective studies. As elective studies, students can complete a minor and/or take individual courses. Individual elective courses can also be taken from other programmes at Aalto University or other Finnish universities through Flexible Study Right (JOO).

Entrepreneurial and multidisciplinary Aalto studies are recommended. Foreign students are encouraged to take Finnish courses.

Also studies completed abroad during student exchange can be included in the elective studies (exchange studies can also form an international minor or be included in the major). Work experience completed in Finland or abroad can also be included in Elective Studies. (SCI students: max. 5 credits. ELEC students: see the internships credit application instructions of the School of Electrical Engineering.)

## Language studies

Compulsory language studies are included as part of the Finnish bachelor's degree for students who have studied in Finland and whose language of education is Finnish or Swedish. If the language studies have not been completed in the student's bachelor's degree, the student must take 2 ECTS in the second national language and 3 ECTS in one foreign language, including both oral and written proficiency.

Students who have received their education in a language other than Finnish or Swedish, or received their education abroad, are required to complete only 3 ECTS in one foreign language, including both oral and written proficiency. Relevant courses (marked with 'o' and 'w') are offered by the Aalto University Language Center.

Students who have received their education abroad and who already have excellent command of English (e.g. English as their first language) may choose 3 credits of Finnish courses instead, hence not covering the requirement of oral/written proficiency but meeting the language requirement of the degree. If this applies to you, please contact your school's Learning Services for further advice, as different schools have different procedures for validating this exemption.

## Minors

Students taking a compact major must have a minor (20-25 credits). Students taking a long major are encouraged to include minor in elective studies. Bachelor level minors may be accepted. The minor is confirmed in the Personal Study Plan (HOPS).

More information on Aalto University's minor subjects:  
[Student Mobility at Aalto: Courses and Minors 2016-2017](#)

## Master's thesis

Students are required to complete a master's thesis, which is a research assignment with a workload corresponding to 30 credits. The thesis is written on a topic usually related to the student's major and agreed upon between the student and a professor who specializes in the topic of the thesis. The supervisor of the thesis must be a professor in the Aalto University. The thesis instructor(s) can be from a company or from another university. Thesis instructor(s) must have at least a master's degree.

Master's thesis work includes a seminar presentation or equivalent presentation. The student is also required to write a maturity essay (ELEC students) or a press release (SCI students) related to the master's thesis.

The master's thesis is a public document and cannot be concealed.

# Majors

This study guide presents the curricula of **CCIS** programme as well as the related international joint programmes [ICT Innovation](#) and [NordSecMob](#).

**CCIS programme** offers eight majors. Some majors have also several tracks.

**Note, that there are some restrictions regarding the selection of major** (students studying bachelor's degree in the School of Science or the School of Electrical Engineering, please check the [available study paths](#)).

The majors and tracks are the following:

- Acoustics and Audio Technology
- Communications Engineering
  - Internet Technologies
  - Wireless communications
  - Communication Ecosystem
- Computer Science
  - Software Systems and Technologies
  - Secure Systems
  - Web Technologies, Applications, and Science
  - Interactive Technologies
  - Algorithms, Logic, and Computation
  - Big Data and Large-Scale Computing
- Game Design and Production
- Machine Learning and Data Mining
- Mobile Computing, Services and Security
- Signal, Speech and Language Processing
  - Signal Processing
  - Speech and Language Processing
- Software and Service Engineering
  - Software Engineering
  - Service Design and Engineering
  - User-Centered Design
  - Enterprise Systems

Some majors offer both long and compact options. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

**ICT Innovation programme** offers the following majors:

- Cloud Computing and Services
- Digital Media Technology
- Embedded Systems
- Human Computer Interaction and Design

- Software and Service Architectures

**NordSecMob programme** has only one major, Security and Mobile Computing.

# Acoustics and Audio Technology

**Professor in charge:** Ville Pulkki (ELEC)

**Professors:** Tapio Lokki (SCI), Lauri Savioja (SCI), Vesa Välimäki (ELEC)

**Extent:** Long (55-65 credits) or compact (40-45 credits) major

**Abbreviation:** AAT

**Code:** ELEC3030

**School:** Electrical Engineering (coordinator) and Science

## Objectives

The major in Acoustics and Audio Technology gives fundamental knowledge about acoustical phenomena, human hearing and audio technologies, and also facilitates the students to apply the knowledge in practice.

The fields of electroacoustics, room and building acoustics, noise, musical acoustics, and audio signal processing are focused in the studies. A central field in the studies is technical psychoacoustics studying human hearing mechanisms, which is a cornerstone in the development of acoustical and audio technologies for human listeners. The fields together constitute the field of communication acoustics, where there exists always a human listener at the end of the acoustic communication channel. Digital signal processing is currently an important tool in acoustics and audio engineering, and the teaching also emphasizes the understanding of its general principles and of fundamental audio processing algorithms.

The target of the major is that the students could use their learning outcome flexibly in different tasks in industry and in academia. For example, the student should know why and how modern lossy audio codecs (mp3, AAC) work, or he/she should be able to measure, understand the perceptual aspects, and design the acoustics of a class room or a noise barrier. Some exemplar fields where the students are foreseen to be competent are sound recording and reproduction, audio coding, music technology, acoustic measurements, active noise cancellation, audio signal processing, room and building acoustics, and environmental noise. If the student wants to work as a certified acoustics consultant in Finland, at least 10 cr on building technology is required.

The research conducted in Aalto University in the fields of this major has focused on following topics: spatial sound reproduction, concert hall acoustics, synthesis of musical instruments and natural sounds, loudspeaker and headphone reproduction, spatial sound psychoacoustics, digital filtering of audio signals, and modeling of room acoustics. The University is facilitated with top-level acoustical laboratories: three anechoic chambers, a standardized multichannel listening room, sound-proof listening booths, and immersive audiovisual environments.

## Content and structure

The major can be completed either as a long (55-65 cr) major or a compact (40-45 cr) major. Students taking the compact major take also a master level minor (20-25 cr). Students taking the long major may include an optional minor in their elective studies.



The major consists of 30 cr of compulsory courses and 10-35 cr of optional courses depending on the choice between long and compact major.

**All the major courses are intended to be studied during the first year of master's studies.** The course ELEC-E5600 Communication Acoustics is a recommended prerequisite to the other major courses.

Code	Name	Credits	Period/Year
<b>Compulsory courses (30 credits):</b>			
<a href="#">ELEC-E0100</a>	Introduction to Master's Studies at Aalto ELEC	0	I-II / 1
<a href="#">CS-E5500</a>	Acoustical Measurements L	5	II / 1
<a href="#">CS-E5510</a>	Room Acoustics L	5	III-IV / 1
<a href="#">ELEC-E5600</a>	Communication Acoustics	5	I / 1
<a href="#">ELEC-E5610</a>	Acoustics and the Physics of Sound	5	II / 1
<a href="#">ELEC-E5620</a>	Audio Signal Processing L	5	III-IV / 1
<a href="#">ELEC-E5630</a>	Acoustics and Audio Technology Seminar L (varying content)	5	IV-V / 1
<b>Optional courses (10-35 credits):</b>			
<a href="#">CIV-E1010</a>	Building Materials Technology	5	I
<a href="#">CIV-E1020</a>	Structural Mechanics: Beams and Frames	5	I
<a href="#">CIV-E3010</a>	Applied Building Physics and Design	5	IV
<a href="#">CIV-E3020</a>	Design of Energy Efficient Buildings	5	II
<a href="#">CIV-E3030</a>	Indoor Air Quality	5	V
<a href="#">CIV-E1050</a>	Heat and Mass Transfer in Buildings	5	II
<a href="#">CS-C3100</a>	Computer Graphics	5	I-II
<a href="#">CS-C3120</a>	Human-computer Interaction	5	I-II
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I
<a href="#">CS-E4200</a>	Emergent User interfaces	5	III-IV
<a href="#">CS-E4850</a>	Computer Vision	5	III-IV
<a href="#">CS-E5520</a>	Advanced Computer Graphics	5	III-V
<a href="#">ELEC-E5410</a>	Signal Processing for Communications	5	I
<a href="#">ELEC-E5420</a>	Convex Optimization for Engineers	5	I-II
<a href="#">ELEC-E5430</a>	Signal Processing for Large Scale Data Analysis L	5	III-IV
<a href="#">ELEC-E5440</a>	Statistical Signal Processing	5	I-II
<a href="#">ELEC-E5500</a>	Speech Processing	5	I
<a href="#">ELEC-E5510</a>	Speech Recognition	5	II
<a href="#">ELEC-E5550</a>	Statistical Natural Language Processing	5	III-IV
<a href="#">ELEC-E5640</a>	Meluntorjunta (Bullerbekämpning, Noise control) L	5	I
<a href="#">ELEC-E5650</a>	Electroacoustics L	5	IV-V
<a href="#">ELEC-E5660</a>	Special assignment in Acoustics and Audio Technology L	1-10	I-II, III-V

## Communications Engineering

**Professor in charge:** Riku Jäntti **Professors:** Riku Jäntti, Jukka Manner, Heikki Hämmäinen

**Extent:** Long major (60 credits)

**Abbreviation:** CE

**Code:** ELEC3029

**School:** Electrical Engineering

## Objectives

The major in Communications Engineering gives a solid understanding of Internet technologies, wireless communications and communications ecosystems - from concepts, technologies and methodologies perspective. Education includes both theoretical and practical aspects of Communications Engineering, preparing the students for a successful career in industry, research organizations or in postgraduate studies without forgetting the professional language and communications skills learned during the education. Students are encouraged to include international, multidisciplinary, and entrepreneurial components as part of their studies.

## Content and structure

**The major offers three different study tracks: wireless communications, internet technologies and communications Ecosystem.** The tracks consist of compulsory part and optional part. Student must follow one of the study tracks. The courses for the optional part of the track must be chosen from the course list specified for that track. In the major there are three courses common to all tracks.

## Communications Engineering - Internet Technologies

The Internet technologies track provides a solid basis for understanding the theory, design principles and practicalities of the core technologies and protocols in the Internet, both in wireless and fixed network communication. In addition to providing theoretical background, many courses involve practical implementation projects that touch the current state-of-the-art Internet protocols and applications.

A graduate from the Internet technologies track understands the fundamentals on Internet architecture and protocols, can perform modeling and analysis on the protocols, and understands security issues in Internet communication. A graduate can also apply this knowledge in practical implementations in real-world use cases, and understand the key factors in providing commercial Internet service. Through a wide selection of optional courses, a graduate is expected to have a deeper understanding on selected topics, such as wireless communication, different networked services, network economics, or cybersecurity.

The track consists of 35 cr of compulsory courses and 25 cr of optional courses

Code	Name	Credits	Period/Year
<b>compulsory courses (35 credits)</b>			
<a href="#">ELEC-E0100</a>	Introduction to Master's Studies at Aalto ELEC	0	I-II / 1
<a href="#">CS-C3130</a>	Information Security	5	I / 2
<a href="#">ELEC-E7110</a>	Trends in Communications Engineering Research	5	I-II / 1
<a href="#">ELEC-E7120</a>	Wireless Systems	5	I / 1

<a href="#">ELEC-E7130</a>	Internet Traffic Measurements and Analysis	5	I / 1
<a href="#">ELEC-E7310</a>	Routing and SDN	5	II / 1
<a href="#">ELEC-E7320</a>	Internet Protocols	5	III-IV / 1
<a href="#">ELEC-E7330</a>	Laboratory Course in Internet Technologies	5	I-II / 2
<b>Optional courses (choose 25 credits):</b>			
<a href="#">CS-E4300</a>	Network Security	5	II / 2
<a href="#">CS-E4310</a>	Mobile Systems Security	5	III-IV / 1
<a href="#">ELEC-A7901</a>	Internet Forum L V *	5	I-II / 1
<a href="#">ELEC-E7210</a>	Communication theory	5	I-II / 1
<a href="#">ELEC-E7220</a>	Radio Resource and Spectrum Management P	5	IV / 1
<a href="#">ELEC-E7230</a>	Mobile Communication Systems	5	I / 2
<a href="#">ELEC-E7260</a>	Machine Learning for Mobile and Pervasive Systems	5	II-III / 1
<a href="#">ELEC-E7420</a>	Network service provisioning	5	I-II / 2
<a href="#">ELEC-E7450</a>	Performance Analysis P	5	V / 1
<a href="#">ELEC-E7460</a>	Modelling and Simulation P	5	I-II / 2
<a href="#">ELEC-E7470</a>	Cybersecurity P	5	V / 1
<a href="#">ELEC-E7810</a>	Patterns in Communications Ecosystems	5	IV-V / 1
<a href="#">ELEC-E7820</a>	Operator Business P	5	I / 2
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5	II / 1
<a href="#">ELEC-E7910</a>	Special Project in Communications Engineering	2-10	I, II, III, IV, V

\*Can be included only once in MSc studies and only as a 5 cr (or more) version

## Communications Engineering - Wireless Communications

The Wireless Communications track focuses on various physical layer, link layer and network layer techniques utilized in modern wireless communication systems as well as the methods that are utilized to design, evaluate and deploy them. The optional courses of the track allows the student to focus either on physical layer characteristics and related signal processing methods, wireless communication system level aspects or networking related aspects.

A graduate from the Wireless Communications track understands main operation principles, characteristics, limitations, and evolution paths of the most common radio systems; understands the principles of radio network planning and optimization; is able to evaluate the system performance and develop new system concepts and algorithms. A graduate can also apply this knowledge in practical implementations in real-world use cases.

The track consists of 40 cr of compulsory courses and 20 cr of optional courses

Code	Name	Credits	Period/Year
<b>Compulsory courses (15 credits):</b>			
<a href="#">ELEC-E0100</a>	Introduction to Master's Studies at Aalto ELEC	0	I-II / 1
<a href="#">ELEC-E7110</a>	Trends in Communications Engineering Research	5	I-II / 1
<a href="#">ELEC-E7120</a>	Wireless Systems	5	I / 1

<a href="#">ELEC-E7130</a>	Internet Traffic Measurements and Analysis	5	I / 1
<b>Compulsory courses (select at least 25 credits)</b>			
<a href="#">ELEC-E7210</a>	Communication Theory	5	I-II / 1
<a href="#">ELEC-E7220</a>	Radio Resource and Spectrum Management P	5	IV / 1
<a href="#">ELEC-E5410</a>	Signal Processing for Communications	5	I-II / 2
<a href="#">ELEC-E7230</a>	Mobile Communication Systems	5	I / 2
<a href="#">ELEC-E7250</a>	Laboratory Course in Communications Engineering	5	III-V / 1
<a href="#">ELEC-E7240</a>	Coding Methods P	5	III / 1
<b>Optional courses (choose to fulfill 60 credits):</b>			
<a href="#">CS-C3130</a>	Information Security	5	I / 2
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I / 1
<a href="#">CS-E4120</a>	Scalable Cloud Computing I-II	5	I-II / 2
<a href="#">CS-E4310</a>	Mobile Systems Security	5	III-IV / 1
<a href="#">CS-E4600</a>	Algorithmic Methods of Data Mining	5	I / 2
<a href="#">ELEC-A7901</a>	Internet Forum LV*	5	I-II / 1
<a href="#">ELEC-E4420</a>	Microwave Engineering I	5	III-IV / 1
<a href="#">ELEC-E5420</a>	Convex Optimization for Engineers	5	I-II / 2
<a href="#">ELEC-E5440</a>	Statistical Signal Processing	5	I-II / 2
<a href="#">ELEC-E7260</a>	Machine Learning for Mobile and Pervasive systems P	5	II-III / 1
<a href="#">ELEC-E7310</a>	Routing and SDN	5	II / 1
<a href="#">ELEC-E7320</a>	Internet Protocols	5	III-IV / 1
<a href="#">ELEC-E7330</a>	Laboratory course in Internet Technologies	5	I-II / 2
<a href="#">ELEC-E7410</a>	Communication Transmission lines	5	V / 1
<a href="#">ELEC-E7450</a>	Performance Analysis P	5	V / 1
<a href="#">ELEC-E7460</a>	Modelling and Simulation P	5	II / 2
<a href="#">ELEC-E7470</a>	Cybersecurity P	5	V / 1
<a href="#">ELEC-E7910</a>	Special Project in Communications Engineering	2-10	I,II,III,IV,V

\*Can be included only once in MSc studies

## Communications Engineering - Communications Ecosystem

The Communications Ecosystems track has a systems-oriented curriculum, offering education in the areas of technology, economics, and user behavior in the context of communications networks and services. Students learn multiple skills and systems thinking, and will be able to collaborate with experts of other fields, such as economics, sociology, and design. The core competence of graduates is technical, business, and social mastery of communication systems.

The track consists of 60 cr, of which 38-41 cr consist of compulsory courses. In the optional courses it's possible to focus on human centric communications or networking business or take more technical courses. Courses can also be chosen from all groups.

Code	Name	Credits	Period/Year
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**Compulsory courses (38-41 credits):**

<a href="#">ELEC-E0100</a>	Introduction to Master's Studies at Aalto ELEC	0	I-II / 1
<a href="#">ELEC-E7110</a>	Trends in Communications Engineering Research	5	I-II / 1
<a href="#">ELEC-E7120</a>	Wireless Systems	5	I / 1
<a href="#">ELEC-E7130</a>	Internet Traffic Measurements and Analysis	5	I / 1
<a href="#">ELEC-E7810</a>	Patterns in Communications Ecosystems	5	IV-V / 1
<a href="#">ELEC-E7820</a>	Operator Business P	5	I / 2
<a href="#">ELEC-E7830</a>	Value Network Design for Internet Services	5	III-IV / 1
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5	II / 1
<a href="#">TU-E2000</a>	Aalto Introduction to Services	3-6	I / 2

**Optional courses (choose to fulfill 60 credits):****Human Centric Communications**

<a href="#">CS-E4400</a>	Design of WWW Services	5	I-II / 2
<a href="#">CS-E4840</a>	Information Visualization	5	IV / 2
<a href="#">CS-E5610</a>	Social Media	4	I-II / 2
<a href="#">ELEC-E7861</a>	Research Project in Human-Computer Interaction P	5-10	III-IV / 1
<a href="#">ELEC-E7880</a>	Quality of Experience	3	I-IV
<a href="#">ELEC-E7890</a>	User Research P	5	I / 1

**Networking Business**

<a href="#">ELEC-A7901</a>	Internet Forum LV	5	I-II / 1
<a href="#">TU-C2010</a>	Introduction to Strategic Management	5	I-II / 1
<a href="#">TU-E2110</a>	Innovation in Operations and Service	3-5	III-IV / 1
<a href="#">TU-E4040</a>	Opportunity Prototyping	3	I / 1

**Other recommended courses**

<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I / 2
<a href="#">ELEC-E7310</a>	Routing and SDN	5	II / 1
<a href="#">ELEC-E7320</a>	Internet Protocols	5	III-IV / 1

# Computer Science

**Professor in charge:** Petri Vuorimaa**Extent:** Long or compact major (40-65 credits). Students taking a compact major take also a minor (20-25 cr). Students taking a long major may include an optional minor in their elective studies.**Abbreviation:** CS**Code:** SCI3042**School:** School of Science**Objectives**

Computer Science major combines both theoretical and applied computer science. The faculty includes over 25 professors. The major has common core courses and six different tracks, which focus on algorithms, software systems, security, interaction, Web, and Big Data. In addition, the major offers a wide range of advanced courses. Students typically do their Master's thesis in industry. Students interested in postgraduate studies can also do their thesis in research projects of Aalto University.

## Content and Structure

Available study tracks:

- Software Systems and Technologies
- Secure Systems
- Web Technologies, Applications, and Science
- Interactive Technologies
- Algorithms, Logic, and Computation
- Big Data and Large-Scale Computing

## Major core courses

Students have to select at least five courses from the major core course list, including the track compulsory core course. The core courses can also be done as part of Bachelor studies. If any of these courses have been taken as part of the Bachelor studies, they can be substituted with any optional courses of the track the student is studying. In addition to major core courses, each track has compulsory and optional courses.

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-C3140</a>	Operating Systems	5	I/1st year
<a href="#">CS-C3170</a>	Web Software Development	5	II-III/1st year
<a href="#">CS-C3130</a>	Information Security	5	I/1st year
<a href="#">CS-C3100</a>	Computer Graphics	5	I-II/1st year
<a href="#">CS-E3190</a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#">CS-E3200</a>	Discrete Models and Search	5	III-IV/1st year
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I/1st year
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5	II/1st year

## Software Systems and Technologies

**Professor in charge:** Keijo Heljanko

**Extent:** Long (55-65 credits) or compact (40-45 credits) major as CS track. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

**Abbreviation:** SST

## Objectives

The Software Systems and Technologies track covers a wide range of topics on software systems, including mobile and cloud computing, energy efficiency of computing, novel networking technologies, and pervasive applications built on top of this basic foundation. The focus of the program is on applied computer science building on a solid software systems technology background. In this track it is also possible to study advanced learning technologies for education.

The students graduating from the track will have a strong technical background on many of the modern core technologies for mobile and cloud based applications. Students interested in pursuing doctoral studies after their M.Sc. degree can easily transfer to the Helsinki Doctoral Education Network in Information and Communications Technology (HICT).

## Learning Outcomes

The graduates of the Software Systems and Technologies track will be able to create and analyze large software systems. The main areas of software systems covered are mobile and cloud computing, energy efficiency of computing, novel networking, and pervasive applications. The track focuses on applied computer science building on a solid software systems background. It is also possible to study advanced learning technologies for education through this track.

## Content and structure

Students have to select at least five courses from the major core course list, including the track compulsory core course. The core courses can also be done as part of Bachelor studies. If any of these courses have been taken as part of the Bachelor studies, they can be substituted with any optional courses of the track.

In addition to major core courses, the students have to take the track compulsory courses. They can also include courses from the optional courses list of the track.

### Major core courses, compulsory major core course bolded (min 25 credits)

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-C3140</a>	<b>Operating Systems</b>	5	I/1st year
<a href="#">CS-C3170</a>	Web Software Development	5	II-III/1st year
<a href="#">CS-C3130</a>	Information Security	5	I/1st year
<a href="#">CS-C3100</a>	Computer Graphics	5	I-II/1st year
<a href="#">CS-E3190</a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#">CS-E3200</a>	Discrete Models and Search	5	III-IV/1st year
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I/1st year
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5	II/1st year

### Track compulsory courses (15 credits)

Code	name	credits	period/year
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5	I-II/1st year
<a href="#">CS-E4000</a>	Seminar on Computer Science	5	I-II or III-V/1st year
<a href="#">CS-E4110</a>	Concurrent Programming	5	I-II/2nd year



## Track optional courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5	I-II/2nd year
<a href="#">CS-E4130</a>	Computer Networks II – Advanced Features	5	I-II
<a href="#">CS-E4140</a>	Applications and Services in Internet	5	I-II
<a href="#">ELEC-E8408</a>	Embedded Systems Development	5	III-IV
<a href="#">CS-E4160</a>	Laboratory Works in Networking and Security	5-10	I-II
<a href="#">CS-E4170</a>	Mobile Systems Programming	5	III-IV/1st year
<a href="#">CS-E4180</a>	Internet Technologies for Mobile Computing	2-10	IV
<a href="#">CS-E4005</a>	Methods and Tools for Network Systems	5	I
<a href="#">CS-E4210</a>	Learning Technologies	5	I-II
<a href="#">CS-E4220</a>	Research Methods	5-8	III-IV
<a href="#">CS-E4230</a>	Transaction Management in Databases	5	III-IV
<a href="#">CS-E4240</a>	Johdatus kääntäjätieteeseen	5	I-II
<a href="#">CS-E4520</a>	Computer Aided Verification and Synthesis	5	III-IV
<a href="#">CS-E4580</a>	Programming Parallel Computers	5	V

## Secure Systems

**Professor in charge:** Tuomas Aura

**Extent:** Long (55-65 credits) or compact (40-45 credits) major as CS track. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

### Objectives

Information security is a basic requirement for all new products and services that make use of software or network connections. The Secure Systems track covers the fundamental models and technologies of computer and network security, such as access control and data protection, as well as timely topics in the security of mobile, embedded and cloud-based systems. Students will learn to analyze threats caused by a creative adversary and to design secure, usable and deployable security solutions. The track also provides a view to current research in systems security. Students are encouraged to combine information-security studies with learning product development skills in some application area.

### Content and structure

The major consists of core courses, track courses, and elective computer-science courses. The purpose of the core courses is to ensure that all students in the major have a solid basic knowledge of computer science and software technology topics. The track courses provide deeper understanding of a specific topic and sufficient background knowledge for the Master's thesis in the track's area. After the core and track courses, most students will be left with quite a few credits for other computer-science courses.



More specifically, students have to select at least five courses from the major core course list, including the compulsory core course(s) defined by the track. The core courses can also be done as part of the Bachelor studies, which reduces the number of core course required at the Master level. Students who have completed equivalent courses at another university can be excused from taking the core courses. In addition to the major core courses, the students have to take the track compulsory courses. The track optional courses are recommended but not required. The rest of the credits for the major can consist of any Master-level computer science courses.

### Major core courses, compulsory major core course bolded (min 25 credits)

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#"><u>CS-C3130</u></a>	<b>Information Security</b>	<b>5</b>	<b>I/1st year</b>
<a href="#"><u>CS-C3140</u></a>	Operating Systems	5	I/1st year
<a href="#"><u>CS-C3170</u></a>	Web Software Development	5	II-III/1st year
<a href="#"><u>CS-C3100</u></a>	Computer Graphics	5	I-II/1st year
<a href="#"><u>CS-E3190</u></a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#"><u>CS-E3200</u></a>	Discrete Models and Search	5	III-IV/1st year
<a href="#"><u>CS-E3210</u></a>	Machine Learning: Basic Principles	5	I/1st year
<a href="#"><u>ELEC-E7851</u></a>	Computational User Interface Design	5	II/1st year

### Track compulsory courses (min 10 credits)

CODE	NAME	CREDITS	PERIOD/YEAR
<b>SELECT AT LEAST TWO OF THE FOLLOWING*:</b>			
<a href="#"><u>CS-E4300</u></a>	Network Security	5	II
<a href="#"><u>CS-E4310</u></a>	Mobile Systems Security	5	III-IV/1st year
<a href="#"><u>CS-E4000</u></a>	Seminar in Computer Science	5	I-II, III-V

\*Students who have no other computer-science seminar course in their Master's degree must select CS-E4000

### Track optional courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#"><u>CS-E4320</u></a>	Cryptography and Data Security	5	I-II
<a href="#"><u>CS-E4160</u></a>	Laboratory Works in Networking and Security	5-10	III-IV
<a href="#"><u>CS-E4330</u></a>	Special Course in Information Security	2-10	I-II, III-IV, V
<a href="#"><u>CS-E4520</u></a>	Computer-Aided Verification and Synthesis	5	III-IV

## Web Technologies, Applications and Science

**Professor in charge:** Petri Vuorimaa

**Extent:** Long (55-65 credits) or compact (40-45 credits) major as CS track. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an

optional minor in their elective studies.

**Abbreviation:** WEB

## Objectives

Web may be the most important invention in the field of data processing since the invention of the computer itself, when the influence on society and business life is considered. The teaching in the Web Technologies, Applications, and Science track handles subject areas of web services and web content in a versatile way. The students learn to develop content to the web and control the technologies related to presenting and transferring that data.

One relevant learning goal is the ability to develop web services to the users. In the deeper level this entails intelligent services and applications. Also information retrieval systems and their evaluation are introduced. Other core content is related to developing web services to machines. On the higher levels than XML, the WWW is based on the semantic web technologies, where the core issues are presenting the knowledge, logics and inference. Human labor, structural data or different methods of automatic annotation (structural or statistical methods) are used to create these kinds of structures.

## Content and structure

The students have to select at least five courses from the major core course list, including the track compulsory core course. The core courses can also be done as part of Bachelor studies. If any of these courses have been taken as part of the Bachelor studies, they can be substituted with any optional courses of the track.

In addition to major core courses, the students have to take the track compulsory courses. They can also include courses from the optional courses list of the track.

### Major core courses, compulsory major core courses bolded (min 25 credits)

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-C3170</a>	<b>Web Software Development</b>	<b>5</b>	<b>II-III/1st year</b>
<a href="#">CS-C3130</a>	Information Security	5	I/1st year
<a href="#">CS-C3140</a>	Operating Systems	5	I/1st year
<a href="#">CS-C3100</a>	Computer Graphics	5	I-II/1st year
<a href="#">CS-E3190</a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#">CS-E3200</a>	Discrete Models and Search	5	III-IV/1st year
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I/1st year
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5	II/1st year

### Track compulsory courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E4400</a>	Design of WWW Services	5	I-II/1st year
<a href="#">CS-E4410</a>	Semantic Web	5	III-IV/1st year
<a href="#">CS-E4420</a>	Information Retrieval	5	III-IV/1st year

## Track optional courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E5220</a>	User Interface Construction	5	II/1st year
<a href="#">CS-E4430</a>	Web Services	4	I-II/2nd year
<a href="#">CS-E4440</a>	WWW-applications	4	I-II/2nd year
<a href="#">CS-E4003</a>	Special Assignment in Computer Science	1-10	I-V
<a href="#">CS-E4004</a>	Individual Studies in Computer Science	1-10	I-V
<a href="#">CS-E4000</a>	Seminar in Computer Science	5	I-II, III-IV
<a href="#">CS-E4610</a>	Modern Database Systems	5	III-IV/1st year
<a href="#">CS-E4450</a>	Explorative Information Visualization	5	I-II

## Interactive Technologies

**Professor in charge:** Antti Oulasvirta

**Extent:** Long (55-65 credits) or compact (40-45 credits) major as CS track. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

**Abbreviation:** IxT

### Objectives

There are great expectations toward emerging interactive technologies such as wearable computing, augmented reality, and context awareness, but also many failures. The goal the IxT track is to educate future leaders in interactive technologies. The track introduces the interdisciplinary study of human-computer interaction (HCI) from computer science and engineering perspectives. The curriculum is unique in Finland and in Europe in its focus on computational and technical aspects of user interfaces and deep integration with state-of-the-art research.

Some highlights of the track include:

- Interdisciplinary orientation with focus on computational and engineering aspects of user interfaces
- Prototyping techniques for creative design of technically advanced user interfaces
- Exploiting computer science (e.g. machine learning and optimisation) to analyze user data and solve problems in design
- Interacting with diverse faculty across departments at Aalto as well as University of Helsinki
- An end-to-end project on a state-of-the-art user interface with a company or a research group.

### Learning Outcomes

The curriculum focuses on the software and hardware aspects of interactive technologies, covering input devices, interactive media, interaction techniques, interface technologies, interactive applications, social media, and multimodal interactive systems. In the first courses, students learn the scientific basis in modeling, theories, and methods. As the curriculum progresses, they learn to

apply them to increasingly more realistic design problems. They are introduced to basic aspects of human factors and social sciences relevant in human-computer interaction.

Specialization in Interactive Technologies provides a basis for careers in the ICT industry, public sector, and research. At the end of the specialization, students can go on to careers where they lead design, research, or management. They are well-equipped to approach modern, hard design problems including challenges in interface technologies, algorithms, data, modeling, and communications and networking. However, they are also knowledgeable about the human and social factors affecting the success of interactive systems. They know how to address them in practical interdisciplinary development processes. They have the meta-cognitive skills to drive visions of interactive technology, critically evaluate different approaches to interaction, and to develop competences further by following advanced research literature.

## Content and structure

Students have to select at least five courses from the major core course list, including the track compulsory core course. The core courses can also be done as part of Bachelor studies. If any of these courses have been taken as part of the Bachelor studies, they can be substituted with any optional courses of the track.

In addition to major core courses, the students have to take the track compulsory courses. They can also include courses from the optional courses list of the track and a list of technical background courses.

Some of the courses are organized in collaboration with research groups at the Helsinki Institute for Information Technology HIIT and the University of Helsinki (Computer Science, Social Sciences).

### Major core courses, compulsory major core course bolded (min 25 credits)

In addition to Computational User Interface Design, we recommend Computer Graphics, Machine Learning: Basic Principles, Principles of Algorithmic Techniques, and Web Software Development.

CODE	NAME	CREDITS	PERIOD/YEAR
<b><u>ELEC-E7851</u></b>	<b>Computational User Interface Design</b>	<b>5</b>	<b>II/1st year</b>
<a href="#"><u>CS-C3170</u></a>	Web Software Development	5	II-III/1st year
<a href="#"><u>CS-C3130</u></a>	Information Security	5	I/1st year
<a href="#"><u>CS-C3140</u></a>	Operating Systems	5	I/1st year
<a href="#"><u>CS-C3100</u></a>	Computer Graphics	5	I-II/1st year
<a href="#"><u>CS-E3190</u></a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#"><u>CS-E3200</u></a>	Discrete Models and Search	5	III-IV/1st year
<a href="#"><u>CS-E3210</u></a>	Machine Learning: Basic Principles	5	I/1st year

### Track compulsory courses: Choose minimum 15 credits

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#"><u>CS-E4200</u></a>	Emergent User Interfaces	5	III-IV/1
<a href="#"><u>ELEC-E7861</u></a>	Research Project in Human-Computer Interaction	5-10	IV-V/1-2

<a href="#">ELEC-E7870</a>	Advanced Topics in User Interfaces PV	3-5	V/1-2
<a href="#">ELEC-E7890</a>	User Research	5	I/1-2
<a href="#">CS-E4840</a>	Information Visualization	5	III/1
<a href="#">ELEC-E7880</a>	Quality of Experience	3	I-V/2

### Track optional courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">MUO-E3005</a>	User Inspired Design - Theory	5	I/1-2
<a href="#">CS-E5210</a>	Usability Evaluation	5	IV/1
<a href="#">CS-E5610</a>	Social Media	4	I-II
SP034i/029	Social Psychology of Information and Communication Technologies (University of Helsinki)*	TBT	TBD
<a href="#">CS-C2000</a>	Ihminen havaitsijana	5	III-IV
<a href="#">CS-E4400</a>	Design of WWW Services	5	I-II
<a href="#">CS-E4450</a>	Explorative Information Visualization	5	I-II
582666	Interactive Systems (University of Helsinki, Computer Science)*	6	
<a href="#">DOM-E5088</a>	Game Design Basics Workshop	3	V

\* Students apply for this course through Flexible Study Right Agreement JOO.

### Optional technical courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">ELEC-E7260</a>	Machine Learning for Mobile and Pervasive Systems	5	II-III/2
<a href="#">CS-E4850</a>	Computer Vision	5	III-IV
<a href="#">MS-E2416</a>	Integer Programming	5	IV

## Interactive Technologies

**Professor in charge:** Antti Oulasvirta

**Extent:** Long (55-65 credits) or compact (40-45 credits) major as CS track. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

**Abbreviation:** IxT

### Objectives

There are great expectations toward emerging interactive technologies such as wearable computing, augmented reality, and context awareness, but also many failures. The goal the IxT track is to educate future leaders in interactive technologies. The track introduces the interdisciplinary study of human-computer interaction (HCI) from computer science and engineering perspectives. The

curriculum is unique in Finland and in Europe in its focus on computational and technical aspects of user interfaces and deep integration with state-of-the-art research.

Some highlights of the track include:

- Interdisciplinary orientation with focus on computational and engineering aspects of user interfaces
- Prototyping techniques for creative design of technically advanced user interfaces
- Exploiting computer science (e.g. machine learning and optimisation) to analyze user data and solve problems in design
- Interacting with diverse faculty across departments at Aalto as well as University of Helsinki
- An end-to-end project on a state-of-the-art user interface with a company or a research group.

## Learning Outcomes

The curriculum focuses on the software and hardware aspects of interactive technologies, covering input devices, interactive media, interaction techniques, interface technologies, interactive applications, social media, and multimodal interactive systems. In the first courses, students learn the scientific basis in modeling, theories, and methods. As the curriculum progresses, they learn to apply them to increasingly more realistic design problems. They are introduced to basic aspects of human factors and social sciences relevant in human-computer interaction.

Specialization in Interactive Technologies provides a basis for careers in the ICT industry, public sector, and research. At the end of the specialization, students can go on to careers where they lead design, research, or management. They are well-equipped to approach modern, hard design problems including challenges in interface technologies, algorithms, data, modeling, and communications and networking. However, they are also knowledgeable about the human and social factors affecting the success of interactive systems. They know how to address them in practical interdisciplinary development processes. They have the meta-cognitive skills to drive visions of interactive technology, critically evaluate different approaches to interaction, and to develop competences further by following advanced research literature.

## Content and structure

Students have to select at least five courses from the major core course list, including the track compulsory core course. The core courses can also be done as part of Bachelor studies. If any of these courses have been taken as part of the Bachelor studies, they can be substituted with any optional courses of the track.

In addition to major core courses, the students have to take the track compulsory courses. They can also include courses from the optional courses list of the track and a list of technical background courses.

Some of the courses are organized in collaboration with research groups at the Helsinki Institute for Information Technology HIIT and the University of Helsinki (Computer Science, Social Sciences).

**Major core courses, compulsory major core course bolded (min 25 credits)**

In addition to Computational User Interface Design, we recommend Computer Graphics, Machine Learning: Basic Principles, Principles of Algorithmic Techniques, and Web Software Development.

<b>CODE</b>	<b>NAME</b>	<b>CREDITS</b>	<b>PERIOD/YEAR</b>
<b><u>ELEC-E7851</u></b>	<b>Computational User Interface Design</b>	<b>5</b>	<b>II/1st year</b>
<a href="#"><u>CS-C3170</u></a>	Web Software Development	5	II-III/1st year
<a href="#"><u>CS-C3130</u></a>	Information Security	5	I/1st year
<a href="#"><u>CS-C3140</u></a>	Operating Systems	5	I/1st year
<a href="#"><u>CS-C3100</u></a>	Computer Graphics	5	I-II/1st year
<a href="#"><u>CS-E3190</u></a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#"><u>CS-E3200</u></a>	Discrete Models and Search	5	III-IV/1st year
<a href="#"><u>CS-E3210</u></a>	Machine Learning: Basic Principles	5	I/1st year

**Track compulsory courses: Choose minimum 15 credits**

<b>CODE</b>	<b>NAME</b>	<b>CREDITS</b>	<b>PERIOD/YEAR</b>
<a href="#"><u>CS-E4200</u></a>	Emergent User Interfaces	5	III-IV/1
<a href="#"><u>ELEC-E7861</u></a>	Research Project in Human-Computer Interaction	5-10	IV-V/1-2
<a href="#"><u>ELEC-E7870</u></a>	Advanced Topics in User Interfaces PV	3-5	V/1-2
<a href="#"><u>ELEC-E7890</u></a>	User Research	5	I/1-2
<a href="#"><u>CS-E4840</u></a>	Information Visualization	5	III/1
<a href="#"><u>ELEC-E7880</u></a>	Quality of Experience	3	I-V/2

**Track optional courses**

<b>CODE</b>	<b>NAME</b>	<b>CREDITS</b>	<b>PERIOD/YEAR</b>
<a href="#"><u>MUO-E3005</u></a>	User Inspired Design - Theory	5	I/1-2
<a href="#"><u>CS-E5210</u></a>	Usability Evaluation	5	IV/1
<a href="#"><u>CS-E5610</u></a>	Social Media	4	I-II
SP034i/029	Social Psychology of Information and Communication Technologies (University of Helsinki)*	TBT	TBD
<a href="#"><u>CS-C2000</u></a>	Ihminen havaitsijana	5	III-IV
<a href="#"><u>CS-E4400</u></a>	Design of WWW Services	5	I-II
<a href="#"><u>CS-E4450</u></a>	Explorative Information Visualization	5	I-II
582666	Interactive Systems (University of Helsinki, Computer Science)*	6	
<a href="#"><u>DOM-E5088</u></a>	Game Design Basics Workshop	3	V

\* Students apply for this course through Flexible Study Right Agreement JOO.

**Optional technical courses**



CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">ELEC-E7260</a>	Machine Learning for Mobile and Pervasive Systems	5	II-III/2
<a href="#">CS-E4850</a>	Computer Vision	5	III-IV
<a href="#">MS-E2416</a>	Integer Programming	5	IV

## Big Data and Large-Scale Computing

**Professor in charge:** Aristides Gionis

**Extent:** Long (55-65 credits) or compact (40-45 credits) major as CS track. Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

### Objectives

The track on big data and large-scale computing provides the students with a strong background to cope with the challenges arising from the growth of data and information in our society. The track covers a wide range of topics in data management, data processing, algorithmics, data science, and data analysis. The teaching and instruction of the students is conducted by the leading experts in the focus areas of this track. Excellent students interested in pursuing doctoral studies after their M.Sc. degree can transfer to the Helsinki Doctoral Education Network in Information and Communications Technology (HICT).

### Learning Outcomes

The track aims to educate professionals who are capable of dealing with the different aspects of data management and data analysis. The graduates of the track will be able to cope with the main big data challenges: collecting and storing data, dealing with data complexity and heterogeneity, developing efficient algorithms to process large datasets, building scalable systems in cloud platforms, employing distributed and parallel computing, discovering patterns and hidden structure in the data, building models and making inferences, and learning to visualize large datasets.

### Content and Structure

Students have to select at least five courses from the major core course list, including the track compulsory core course. The core courses can also be done as part of Bachelor studies. If any of these courses have been taken as part of the Bachelor studies, they can be substituted with any optional courses of the track.

In addition to major core courses, the students have to take the track compulsory courses. They can also include courses from the optional courses list of the track. Also other optional courses can be included per agreement with a professor in charge of the track.

**Major core courses, compulsory major core courses bolded (min 25 credits)**

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E3190</a>	<b>Principles of Algorithmic Techniques</b>	<b>5</b>	<b>I-II/1st year</b>
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I/1st year



<a href="#">CS-E3200</a>	Discrete Models and Search	5	III-IV/1st year
<a href="#">CS-C3170</a>	Web Software Development	5	II-III/1st year
<a href="#">CS-C3130</a>	Information Security	5	I/1st year
<a href="#">CS-C3140</a>	Operating Systems	5	I/1st year
<a href="#">CS-C3100</a>	Computer Graphics	5	I-II/1st year
<a href="#">ELEC-E7815</a>	Computational User Interface Design	5	II/1st year

### Track compulsory courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E4600</a>	Algorithmic Methods of Data Mining	5	I-II
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5	I-II
<a href="#">CS-E4610</a>	Modern Database Systems	5	III-IV

### Track optional courses

Code	Name	Credits	Period/Year
<a href="#">CS-E4580</a>	Programming Parallel Computers	5	V
<a href="#">CS-E4800</a>	Artificial Intelligence	5	III-IV
<a href="#">CS-E4830</a>	Kernel Methods in Machine Learning	5	I-II
<a href="#">CS-E4520</a>	Computer-Aided Verification and Synthesis	5	III-IV
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5	II
<a href="#">CS-E4820</a>	Machine Learning: Advanced Probabilistic Methods	5	III-IV
<a href="#">CS-E4850</a>	Computer Vision	5	III-IV
<a href="#">CS-E4840</a>	Information Visualization	5	IV
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5	I-II
<a href="#">ELEC-E5510</a>	Speech Recognition	5	II
<a href="#">ELEC-E5420</a>	Convex Optimization for Engineers L	7	I-II
<a href="#">CS-E4500</a>	Advanced Course in Algorithms	5	III-IV
<a href="#">CS-E4110</a>	Concurrent Programming	5	I-II
<a href="#">CS-E4870</a>	Research Project in Machine Learning and Data Science	10	I-II

Also optional courses can be included per agreement with a professor in charge of the track.

## Game Design and Production

**Professor in charge:** Perttu Hämäläinen

**Extent:** Long or compact major (40-65 credits). Students taking a compact major take also a minor (20-25 cr). Students taking a long major may include an optional minor in their elective studies.

**Code:** SCI3046

**School:** School of Science

### Objectives

The objective of the major is to educate programmer-designers\* that understand both technology and the player's point of view, and can thus 1) participate in overall game design and 2) take responsibility of the myriad design decisions that are not necessarily communicated in a design document and only arise during implementation.

The students will learn about game design, production, and technology using a project-oriented, hands-on with minds-on approach. The project courses emphasize interdisciplinary and collaborative work. The teacher network includes both game industry professionals and game scholars.

\* You may also substitute "engineer" or "computer scientist" for "programmer"

## Learning Outcomes

- Deepening of technological expertise already built during Bachelor level studies (compulsory technical courses on computer graphics, machine learning, and artificial intelligence)
- Building a wide set of cross-disciplinary design, production, and teamworking skills (compulsory Department of Media courses, especially DOM-E5095 game project, during which multiple games are developed).
- Deeper understanding of each student's specific areas of interest (large selection of elective courses that can be included in the personal study plan).

## Structure and content

The Game Design and Production major is organized in collaboration with Media Lab Helsinki of Aalto ARTS, which has an M.A. in New Media "sibling major" with the same name. Computer and video games is a multidisciplinary field, and the M.Sc. and M.A. majors share a large portion of the courses. The obligatory courses differ, however, and the CCIS students should expect to work in a more technical role, e.g., when creating a joint thesis game with ARTS students. Multidisciplinarity is also emphasized by the high flexibility of elective studies, where one can include, e.g., 3D animation, interactive storytelling and interaction design in addition to computer science.

Students take the Major compulsory courses. In addition, they take Major optional courses. Listing of optional courses is not exhaustive. Additionally, students may choose courses from all Aalto schools according to the personal study plan. It is strongly suggested that students venture outside their comfort zone and do not, for example, take a course in web software development if they already possess the equivalent skills and knowledge.

## Major compulsory courses

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-C3100</a>	Computer Graphics	5	I-II
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I
<a href="#">CS-E4800</a>	Artificial Intelligence	5	III-IV
<a href="#">DOM-E0000</a>	Understanding Media, Art and Design	4	I/1st year
<a href="#">DOM-E5080</a>	Game Design	5	I
<a href="#">DOM-E5083</a>	Game Analysis	5	III-V

<a href="#">DOM-E5095</a>	Game Project	5-15	I-V/1st year
<a href="#">DOM-E5093</a>	Game Design Exam	1	III,V
<a href="#">DOM-E5001</a>	Personal study plan	1	I/1st year

**Recommended optional courses (students may also suggest others as game design is a multidisciplinary field).**

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">DOM-E5094</a>	Advanced Topics in Game Design	3-5	I
<a href="#">DOM-E5082</a>	Playability Evaluation	3	III
<a href="#">DOM-E5087</a>	Action Games	3-5	V
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2	I-II
<a href="#">DOM-E5038</a>	Generative and Interactive Narratives	3	III-V
<a href="#">DOM-E5066</a>	Introduction to Sound Design and Music	1-5	I
<a href="#">DOM-E5029</a>	Introduction to 3D Animation	4	I
<a href="#">DOM-E5058</a>	Information Visualization and Design	3-6	III
<a href="#">CS-E4840</a>	Information Visualization	5	IV
<a href="#">ELEC-E7851</a>	Computational User Interface Design		II
<a href="#">CS-E4200</a>	Emergent User Interfaces	5	III-IV
<a href="#">CS-C3120</a>	Human-Computer Interaction	5	I-II
<a href="#">CS-E5520</a>	Advanced Computer Graphics	5	III-V
<a href="#">CS-C3170</a>	Web Software Development	5	II-III/1st year
<a href="#">CS-C3130</a>	Information Security	5	I/1st year
<a href="#">CS-E3190</a>	Principles of Algorithmic Techniques	5	I-II/1st year
<a href="#">CS-E3200</a>	Discrete Models and Search	5	III-IV/1st year
<a href="#">CS-E4580</a>	Programming Parallel Computers	5	V
<a href="#">CS-E4830</a>	Kernel Methods in Machine Learning	5	I-II
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5	II
<a href="#">CS-E4820</a>	Machine Learning: Advanced Probabilistic Methods	5	III-IV
<a href="#">CS-E4850</a>	Computer Vision	5	III-IV
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5	I-II

## ICT Innovation

**Please note that this is a double degree programme implemented through international collaboration which is why its structure may deviate from the regular structure of the Master's Degree Programme in Computer, Communication and Information Sciences.**

<b>Degree(s) awarded</b>	Master of Science (Technology ) from Aalto University Master of Science or similar degree from partner university
<b>Majors</b>	Digital Media Technology (SCI3023)

Cloud Computing and Services (SCI3081)  
 Embedded Systems (SCI3024)  
 Human-Computer Interaction and Design (SCI3020)  
 Service Design and Engineering (SCI3022)/  
 Software and Service Architectures (SCI3082)  
**Minor** Innovation & Entrepreneurship (SCI3039)

## Contact information

**Programme website:** <http://www.masterschool.eitdigital.eu/>

**Into:** <https://into.aalto.fi/display/eneitictinno/>

**Administration:** Study Coordinator Päivi Koivunen, Study Affairs Secretary Kitta Peura (student affairs)

**Head of the programme:** Prof. Petri Vuorimaa

## Programme description

Master's Programme in ICT Innovation is a European double degree programme for students who want to know both the technical and entrepreneurial aspects of information and communications technology. The ICT Innovation programme follows the general structure of the EIT Digital Master School. It is a full-time two-year 120 ECTS master's programme, combining a 90 ECTS technical part with a 30 ECTS standardised module on Innovation and Entrepreneurship (I&E). The programme is completed by studying at two different universities in two countries. Graduates will receive a Master's degree from both of these universities. Aalto University offers five majors within the ICT Innovation programme.

## Admission criteria

A degree equivalent to a Bachelors degree of 180 ECTS credits. The specific admission requirements vary for each major. The language of instruction of the programme is English. The applicants must have an excellent command of English. For further information on admission, application deadline and English language proficiency please see [www.masterschool.eitdigital.eu](http://www.masterschool.eitdigital.eu).

## Mobility of students

The table below describes the study track options currently available in EIT Digital Master School in the five majors where Aalto University is involved. First year universities are called entry universities and second year universities are exit universities. Some universities are only available as exit points.

University name and country	Cloud Computing and Services	Digital Media Technology	Embedded Systems	Human Computer Interaction and Design	Service Design and Engineering/ Software and Service Architectures
Aalto University	Entry + Exit	Exit	Exit	Entry + Exit	Entry + Exit

School of Science, Finland					
Budapest University of Technology and Economics, Hungary		Exit	Exit		Exit
Eötvös Loránd University, Budapest, Hungary					Entry + Exit
KTH Royal Institute of Technology, Stockholm, Sweden	Exit	Entry + Exit	Entry + Exit	Entry + Exit	
Technische Universität Berlin, Germany	Entry + Exit		Entry + Exit	Exit	
Delft University of Technology, The Netherlands	Entry + Exit	Entry + Exit			
Eindhoven University of Technology, The Netherlands			Entry + Exit		Exit
University of Twente, The Netherlands				Entry + Exit	
University of Trento, Italy		Exit	Exit	Exit	Entry + Exit
University of Turku, Finland			Exit		
Université Paris- Sud, France	Exit			Entry + Exit	
University of Rennes 1, France	Entry + Exit				
Åbo Akademi University, Turku, Finland			Exit		
Universidad Politécnica de Madrid, Spain					Exit
University College London		Exit		Exit	

## Programme structure

20-30 ECTS Mandatory courses  
30-40 ECTS Elective and Specialized courses  
30 ECTS Innovation & Entrepreneurship Minor  
30 ECTS Master's Thesis

## Language courses for all majors

According to the degree regulations at Aalto University, students must take at least 3 ECTS of foreign language studies for the degree. In Master's Programme in ICT Innovation the students have the option to choose between an English course, fulfilling both oral and written requirements (o,w) or at least 3 ECTS of Finnish courses. We recommend the English course [LC-1310](#)

Academic Communication for MSc Students for everyone. Taking the Finnish course(s) as part of the degree requires an application for exemption from the foreign language course requirement. Please contact your study affairs secretary for more information.

## Innovation & Entrepreneurship Minor

**Coordinator in charge:** Olli-Pekka Mutanen

The I&E minor at Aalto is developed in co-operation with the Aalto Venture Program (AVP, <http://avp.aalto.fi/>). The focus of the Aalto I&E program is on entrepreneurship in ICT. The content of I&E minor is same for all five majors.

### Compulsory I&E courses during the entry year 2016-2017 and summer 2017

Code	Course name	Credits
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2 ECTS
<a href="#">CS-E5110</a>	Management of a Technology Venture	5 ECTS
<a href="#">TU-E4100</a>	Startup Experience	9 ECTS
<a href="#">CS-E5440</a>	Growth and Internationalization of Technology SMEs	4 ECTS
<a href="#">CS-E5430</a>	ICT Innovation Summer School	4 ECTS

### Compulsory I&E course during the second year 2016-2017

Code	Course name	Credits
<a href="#">CS-E5420</a>	ICT Innovation I&E Minor Thesis	6 ECTS

## Digital Media Technology

Entry points: KTH and TU Delft

Exit points with specializations:

AALTO: Hypermedia  
KTH: Media Processing and Communications  
TU Delft: Medical Imaging  
BME: Media Communications Services  
UNITN: Semantic Media  
UCL: Virtual Environments

**Professor in charge:**

Petri Vuorimaa

**Other professors of the major:**

Eero Hyvönen

## Objectives of the programme

The main focus of the Digital Media Technology (DMT) technical major is on the enabling technologies for digital media systems, including technologies for generation of (interactive) media, processing and coding of media and for wired and wireless transfer and storage of media content.

Applications that use these technologies include teleconferencing, interactive multimedia applications, entertainment, computer games, telemedicine and surveillance etc. The master will be based on a systems engineering approach in order to successfully integrate media technologies in applications such as “smart spaces”, “health and well-being”, and “smart cities”, thematic areas of EIT Digital.

## Second year at Aalto

Aalto specialization – Hypermedia

### Second autumn 2016

#### Compulsory major courses (16 ECTS)

Code	Course name	Credits
<a href="#">CS-E4430</a>	Web Services	4 ECTS
<a href="#">CS-C3170</a>	Web Software Development	5 ECTS
<a href="#">CS-E4440</a>	WWW Applications	4 ECTS
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS

(\* ) See ‘Language courses for all majors’ above.

#### Compulsory I&E Courses (6 ECTS)

Code	Course name	Credits
CS-E5420	ICT Innovation I&E Minor Thesis	6 ECTS

## Optional Courses (8 ECTS)

Code	Course name	Credits
<a href="#">CS-E4003</a>	Special Assignment in Computer Science	1-10 ECTS
<a href="#">CS-E4450</a>	Explorative Information Visualization	5 ECTS
<a href="#">CS-E5220</a>	User Interface Construction	5 ECTS
<a href="#">CS-E4000</a>	Seminar in Computer Science	5 ECTS
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5 ECTS
<a href="#">CS-E4140</a>	Applications and Services in Internet	5 ECTS
<a href="#">CS-E5610</a>	Social Media	4 ECTS

**Total 30 ECTS**

## Second spring 2017

Code	Course name	Credits
CS.thes	Master's Thesis*	30 ECTS

**Total for the whole year: 60 ECTS**

\*NOTE: According to Finnish legislation, a master's thesis is a public document and its contents cannot be confidential. Therefore, the material of the thesis must be chosen so that it does not include any information that could be classified as a business secret of the financing company.

## Cloud Computing and Services

Entry points: AALTO, TU Berlin, TU Delft and U Rennes 1

Exit points with specializations:

AALTO: Mobile Services

KTH: Data Intensive Computing

TU Berlin: Cloud operation

TU Delft: Distributed Data Processing

UPS: Distributed Information Management

U Rennes 1: Cloud Infrastructures

**Professor in charge:**

Associate professor Keijo Heljanko

**Other professors of the major:**

Tuomas Aura

N. Asokan

Mario di Francesco

## Objectives of the programme

The program objective is to educate engineers who will be able to design, implement and maintain distributed software systems for a wide range of applications including peer-to-peer, cloud computing, web-services provision and internet-based applications. The program will provide



students with a system of knowledge both in formal foundations, technological platforms and practical skills in implementing distributed software applications. The program will also provide an insight into current and future directions of the distributed software development.

Graduates of the programme are able to

- analyse and design a complex distributed IT-system based on network, storage, and processing components
- describe a service-based system using dedicated description languages
- calculate and assess the necessary quantitative capacities of the system components to achieve specified performance goals
- can apply up-to-date technology in fault tolerance and security to achieve privacy and dependability goals in complex distributed systems
- identify business opportunities in the area of cloud computing and to turn them into operation
- communicate technical issues to professionals and non-professionals
- work in multidisciplinary and multinational teams and take over responsibilities
- have business skills to understand and execute a business development process, and have insight in legal and societal aspects of products and services

## First year at Aalto

### First autumn 2016

#### Compulsory courses (23 ECTS)

Code	Course name	Credits
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5 ECTS
<a href="#">CS-E4130</a>	Computer Networks II – Advanced Features	5 ECTS
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5 ECTS
<a href="#">CS-E4005</a>	Methods and Tools for Network Systems	5 ECTS
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS

(\*) See ‘Language courses for all majors’ above.

#### Compulsory I&E Courses (7 ECTS)

Code	Course name	Credits
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2 ECTS
<a href="#">CS-E5110</a>	Management of a Technology Venture	5 ECTS

## First spring 2017

### Compulsory courses (5 ECTS)

Code	Course name	Credits
<a href="#">CS-E4000</a>	Seminar in Computer Science	5 ECTS

### Compulsory I&E Courses (17 ECTS)

Code	Course name	Credits
<a href="#">TU-E4100</a>	Startup Experience	9 ECTS
<a href="#">CS-E5440</a>	Growth and Internationalization of Technology SMEs	4 ECTS
<a href="#">CS-E5430</a>	ICT Innovation Summer School	4 ECTS

### Optional courses - select 8 ECTS of over two semesters

Code	Course name	Credits	Semester
<a href="#">CS-E4560</a>	Parallel and Distributed Systems	5 ECTS	autumn
<a href="#">CS-E4140</a>	Applications and Services in Internet	5 ECTS	autumn
<a href="#">CS-C3130</a>	Information Security	5 ECTS	autumn
<a href="#">CS-E4300</a>	Network Security	5 ECTS	autumn
<a href="#">CS-E4002</a>	Special Course in Computer Science	1-10 ECTS	autumn/spring
<a href="#">CS-E4003</a>	Special Assignment in Computer Science	1-10 ECTS	autumn/spring
<a href="#">CS-E4330</a>	Special Course in Information Security	2-10 ECTS	autumn/spring
<a href="#">CS-E4160</a>	Laboratory Works in Networking and Security	5 ECTS	spring
<a href="#">CS-E4170</a>	Mobile Systems Programming	5 ECTS	spring
<a href="#">CS-E4180</a>	Internet Technologies for Mobile Computing	5 ECTS	spring

**Total for the whole year: 60 ECTS**

**Note about master's thesis:** In some exit universities, requirements for master's thesis may be different from Aalto's requirements. A master's thesis done according to the requirements of such an exit university is accepted at Aalto. However, at Aalto the thesis is evaluated and graded according to the guidelines of Aalto. If a section of the thesis is not adequate in terms of Aalto's requirements, it may affect the grade of the thesis. Guidelines for master's thesis evaluation are available in Into: <https://into.aalto.fi/display/enmastersci/Master%27s+thesis#Master'sthesis-Master'sthesisevaluation>

**Note also** that according to Finnish legislation, a master's thesis is a public document and its contents cannot be confidential. Therefore, the material of the thesis must be chosen so that it does not include any information that could be classified as a business secret of the financing company

## Second year at Aalto

Aalto specialization – Mobile Services

The courses cover the theoretical and practical aspects of designing mobile distributed systems and services. In the seminar the students learn to read technical and research literature on selected thematic topics and mobile computing, as well as scientific writing and presentation. In the Master's thesis project, the students can focus on problems arising from the thematic research projects in the Helsinki Node of EIT Digital.

### Second autumn 2017

#### Compulsory courses (18 ECTS)

Code	Course name	Credits
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS
<a href="#">CS-E4000</a>	Seminar in Computer Science	5 ECTS
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5 ECTS
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5 ECTS

(\*) See 'Language courses for all majors' above.

#### Compulsory I&E Courses (6 ECTS)

Code	Course name	Credits
<a href="#">CS-E5420</a>	ICT Innovation I&E Minor Thesis	6 ECTS

#### Optional Courses (6 ECTS)

Code	Course name	Credits
<a href="#">CS-E4560</a>	Parallel and Distributed Systems	5 ECTS

<a href="#">CS-E4160</a>	Laboratory Works in Networking and Security	5 ECTS
<a href="#">CS-E4170</a>	Mobile Systems Programming	5 ECTS
<a href="#">CS-E4140</a>	Applications and Services in Internet	5 ECTS
<a href="#">CS-C3130</a>	Information Security	5 ECTS
<a href="#">CS-E4300</a>	Network Security	5 ECTS
<a href="#">CS-E4005</a>	Methods and Tools for Network Systems	5 ECTS
<a href="#">CS-E4180</a>	Internet Technologies for Mobile Computing	4 ECTS

**Total 30 ECTS**

**Second spring 2017**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
CS.thes	Master's Thesis	30 ECTS

**Total for the whole year: 60 ECTS**

## **Embedded Systems**

Entry points: KTH, TU Berlin and TU/e

Exit points with specializations:

KTH: Embedded Platforms and Internet of Things

AALTO: Mobile Cyber-Physical Systems

TU Berlin: Embedded Multicore Processing

UNITN: Real-Time Systems and Design of Cyber-Physical systems

TU/e: Embedded Networking

UTU and ÅA: Energy Efficient Computing

BME: Critical Embedded Systems

**Professor in charge:**

Stavros Tripakis

**Academic coordinator**

Vesa Hirvisalo

### **Objectives of the programme**

Cyber-physical systems (CPS) combine computational and physical elements. A mobile CPS is designed as a network that includes mobile and wireless elements. The technology for mobile CPS forms the corner stone for many novel application areas and businesses, such as augmented and mixed reality systems, infotainment systems, and games. Especially, the rise in popularity of smartphones has increased interest in the area of mobile CPS. The students will acquire skills to develop applications and services that are based on mobile CPS technologies. The topics covered include programming web and multimedia systems, processing of video and audio, designing user interfaces, and mastering the embedded systems design flow.

**Second year at Aalto**

## Aalto specialization – Mobile Cyber-Physical Systems

### Second autumn 2016

#### Compulsory courses

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-C3170</a>	Web Software Development	5 ECTS
<a href="#">CS-E5470</a>	Seminar on embedded systems	3-10 ECTS
<a href="#">CS-E5460</a>	Project in embedded systems	5-10 ECTS
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS

(\*) See 'Language courses for all majors' above.

#### Compulsory I&E Courses

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E5420</a>	ICT Innovation I&E Minor Thesis	6 ECTS

#### Optional courses

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">ELEC-E5510</a>	Speech Recognition	5 ECTS
<a href="#">CS-E5220</a>	User Interface Construction	5 ECTS
<a href="#">CS-E4430</a>	Web Services	4 ECTS
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5 ECTS

**Total 30 ECTS**

### Second spring 2016

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
CS.thes	Master's Thesis*	30 ECTS

\*NOTE: According to Finnish legislation, a master's thesis is a public document and its contents cannot be confidential. Therefore, the material of the thesis must be chosen so that it does not include any information that could be classified as a business secret of the financing company.

**Total for the whole year: 60 ECTS**

## **Human Computer Interaction and Design**

Entry points: Aalto, KTH, Université Paris-Sud (UPS) and University of Twente (UT)

Exit points with specializations:

KTH: Mobile and ubiquitous interaction

AALTO: User Modeling for advanced human-computer interaction

TU Berlin: Multi-modal interaction

UPS: Situated interaction

UT: Intelligent systems

UNITN: Cognitive Interaction

UCL: Affective Computing

**Professor in charge:**

Marko Nieminen

**Other professors of the major:**

Samuel Kaski

David McGook

**Academic coordinator:**

Mika P. Nieminen

### **Objectives of the programme**

Human Computer Interaction and Design (HCID) focuses on the study, design, development and evaluation of novel user interfaces and interactive systems taking into account human aspects, at the cognitive and sensory-motor levels, technological aspects, as well as business aspects.

New ICT technologies are transforming our daily lives. Smart devices (mobile phones, PDAs, tablet computers), smart products (car, navigation) and smart environments (ambient intelligence) are enabling new services such as navigation, information providing, learning, making reservations or buying of goods are delivered.

Increasingly, the interaction with these devices is not through simple buttons or keystrokes but with more flexible and intuitive interaction methods such as multi-touch, speech, gestures, and with advanced display systems such as augmented and virtual reality. Smart devices and services are also able to show intelligent behaviour recognizing intentions of the user and anticipating the user's needs. These technologies are central in Human-Computer Interaction and Design.

The design of intuitive user interfaces, however, is not only a matter of the right technology but also a matter of good interaction design: study user's social and cognitive behaviour in relation to using technology, taking the user as a central driver for design, designing for the right user experience, and testing and evaluating the design within context, are keys to understanding and designing successful user experience.

### **First year at Aalto**

**First autumn 2016**

**Compulsory courses (13 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS
<a href="#">CS-E4900</a>	User-Centered Methods for Product and Service Design	5 ECTS
<b>Select one of the following courses:</b>		
<a href="#">CS-E5220</a>	User Interface Construction	5 ECTS
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5 ECTS

(\*) See 'Language courses for all majors' above.

### **Compulsory I&E Courses (7 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2 ECTS
<a href="#">CS-E5110</a>	Management of a Technology Venture	5 ECTS

**Total 20 ECTS**

### **First spring 2017**

#### **Compulsory courses (20 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E5200</a>	Design Project	10 ECTS
<a href="#">CS-E5210</a>	Usability Evaluation	5 ECTS
<a href="#">CS-E4200</a>	Emergent User Interfaces	5 ECTS

#### **Compulsory I&E Courses (17 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">TU-E4100</a>	Startup Experience	9 ECTS
<a href="#">CS-E5440</a>	Growth and Internationalization of Technology SMEs	4 ECTS
<a href="#">CS-E5430</a>	ICT Innovation Summer School	4 ECTS

**Total 36 ECTS**

**Optional courses - Select at least 3 ECTS over the two semesters:**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>	<b>Semester</b>
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5 ECTS	autumn
<a href="#">CS-C3100</a>	Computer Graphics	5 ECTS	autumn
<a href="#">CS-E4400</a>	Design of WWW services	4 ECTS	autumn
<a href="#">CS-E4840</a>	Information Visualization	5 ECTS	spring
<a href="#">CS-E4800</a>	Artificial Intelligence	5 ECTS	spring
<a href="#">CS-E5520</a>	Advanced Computer Graphics	5 ECTS	spring

**Total for the whole year: 60 ECTS**

**NOTE about master's thesis:** In some exit universities, requirements for a master's thesis may be different from Aalto's requirements. A master's thesis done according to the requirements of such an exit university is accepted at Aalto. However at Aalto the thesis is evaluated according to the guidelines of Aalto. If a section of a thesis is not adequate in terms of Aalto's requirements, it may affect the grade of the thesis. Guidelines for master's thesis evaluation are available in Into:

<https://into.aalto.fi/display/enmastersci/Master%27s+thesis>

**Note also:** According to Finnish legislation, a master's thesis is a public document and its contents cannot be confidential. Therefore, the material of the thesis must be chosen so that it does not include any information that could be classified as a business secret of the financing company.

## **Second year at Aalto**

Aalto specialization – User Modeling for advanced human-computer interaction

### **Second autumn 2016**

#### **Compulsory courses (8 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles (If basics done at entry university, select more electives)	5 ECTS

(\*) See 'Language courses for all majors' above.

#### **Compulsory I&E Courses (6 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E5420</a>	ICT Innovation I&E Minor Thesis	6 ECTS



## Optional courses (16 ECTS)

Code	Course name	Credits	Period
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5 ECTS	autumn
<a href="#">ELEC-E5510</a>	Speech Recognition	5 ECTS	autumn
<a href="#">ELEC-E7850</a>	User Interfaces	5 ECTS	autumn
<a href="#">CS-E5004</a>	Individual Studies in Software and Service Engineering	1-10 ECTS	autumn/spring
CS-E40xx	Special Course in Machine Learning and Data Science	3-10 ECTS	autumn/spring
<a href="#">CS-E4870</a>	Research Project in Machine Learning and Data Science	5-10 ECTS	autumn/spring
<a href="#">CS-E4600</a>	Algorithmic Methods of Data Mining	5	autumn

**Total: 30 ECTS**

## Second spring 2017

Code	Course name	Credits
CS.thes	Master's Thesis	30 ECTS

**Total for the whole year: 60 ECTS**

- [Innovation & Entrepreneurship Minor](#)
- [Digital Media Technology](#)
- [Cloud Computing and Services](#)
- [Embedded Systems](#)
- [Human Computer Interaction and Design](#)
- [Service Design and Engineering / Software and Service Architectures](#)

## Service Design and Engineering / Software and Service Architectures

NOTE: The name of the major has changed. As of 1.8.2016 the name is Software and Service Architectures (SSA). For students of intake 2015 who study their exit year 2016-2017 in Aalto University the major is, however, Service Design and Engineering.

Entry points: AALTO, UNITN, ELTE

Exit points and specializations:

Aalto: Mobile service systems

TU/e: Service-oriented business process management

ELTE: Distributed service systems

UNITN: Service-oriented social informatics

UPM: Software and Services in the Cloud

**Professor in charge:**

Kari Smolander

**Academic coordinator:**

Håkan Mitts

## Objectives of the programme

The Aalto academic year is divided into 5 periods with courses running in one or in several periods. Also some courses are run as intensive courses and take only half a period. The basic structure of the program for the year 2016-2017 is shown below. The main desideratum for designing the SSA Technical Common Base is to ensure that SSA students, after the first year, have comparable technical understanding of important topics related to SSA.

## First year at Aalto

### First autumn 2016

#### Compulsory courses (18 ECTS)

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">TU-E2000</a>	Aalto Introduction to Services	5 ECTS
<a href="#">CS-E5310</a>	ICT Enabled Service Business and Innovation	5 ECTS
<a href="#">CS-C3170</a>	Web Software Development	5 ECTS
LC-xxxx	Language course: Compulsory degree requirement, both oral and written requirements *	3 ECTS

(\*) See 'Language courses for all majors' above.

#### Compulsory I&E Courses (7 ECTS)

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2 ECTS
<a href="#">CS-E5110</a>	Management of a Technology Venture	5 ECTS

### First spring 2017

#### Compulsory courses (10 ECTS)

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E4930</a>	Software Processes and Projects	5 ECTS
<a href="#">CS-E4950</a>	Software Architectures	5 ECTS

## Compulsory I&E Courses (17 ECTS)

Code	Course name	Credits
<a href="#">TU-E4100</a>	Startup Experience	9 ECTS
<a href="#">CS-E5440</a>	Growth and Internationalization of Technology SMEs	4 ECTS
<a href="#">CS-E5430</a>	ICT Innovation Summer School	4 ECTS

## Optional courses – Select at least 8 ECTS over the two semesters:

Code	Course name	Credits	Period
<a href="#">CS-E5300</a>	Enterprise Architectures (highly recommended)	5 ECTS	Autumn
<a href="#">CS-E4840</a>	Information visualization (highly recommended)	5 ECTS	Spring

Other relevant courses on agreement with the academic coordinator.

## Total for the whole year: 60 ECTS

**NOTE about the master's thesis:** In some exit universities, requirements for a master's thesis may be different from Aalto's requirements. A master's thesis done according to the requirements of such an exit university is accepted at Aalto. However at Aalto the thesis is evaluated according to the guidelines of Aalto. If a section of a thesis is not adequate in terms of Aalto's requirements, it may affect the grade of the thesis. Guidelines for master's thesis evaluation are available in Into:

<https://into.aalto.fi/display/enmastersci/Master%27s+thesis>

**Note also:** According to Finnish legislation, a master's thesis is a public document and its contents cannot be confidential. Therefore, the material of the thesis must be chosen so that it does not include any information that could be classified as a business secret of the financing company.

## Second year at Aalto

Aalto specialization – Mobile Service Systems

The starting point for the second year in SDE at Aalto is to create a personal study plan for each student that matches the student's own interests as well as the needs of the research project that forms the foundation of the student's Master's thesis.

Aalto offers a specialization in Mobile service systems with thematic coupling to Smart Spaces. The courses cover the theoretical and practical aspects of designing digital services with a strong mobile focus. In the Master's thesis project, the students can focus on problems arising from the thematic research projects in the Helsinki Node of EIT Digital.

## Second autumn 2016

### Compulsory courses (3 ECTS)

Code	Course name	Credits
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LC-xxxx Language course: Compulsory degree requirement,  
both oral and written requirements \* 3 ECTS

Other relevant courses on agreement with the academic coordinator.

(\*) See 'Language courses for all majors' above.

### Compulsory I&E Courses (6 ECTS)

Code	Course name	Credits
<a href="#">CS-E5420</a>	ICT Innovation I&E Minor Thesis	6 ECTS

### Optional Courses (21 ECTS)

Code	Course name	Credits
<a href="#">CS-E4100</a>	Mobile Cloud Computing (highly recommended)	5 ECTS
<a href="#">CS-E5002</a>	Special Course in Software and Service Engineering (highly recommended)	10 ECTS

Other relevant courses on agreement with the academic coordinator.

**Total 30 ECTS**

### Second spring 2017

Code	Course name	Credits
CS.thes	Master's Thesis	30 ECTS

**Total for the whole year: 60 ECTS**

# Machine Learning and Data Mining

**Professor in charge:** Samuel Kaski

**Extent:** Long major (55-65 credits). Compact major is not offered. Students who want to take a minor are encouraged to include it in elective studies.

**Abbreviation:** Macadamia

**Code:** SCI3044

**School:** School of Science

## Objectives

The major in Machine Learning and Data Mining (Macadamia) gives a strong basic understanding of modern computational data analysis and modelling methodologies. It builds on the strong

research at the Department of Computer Science. The methods of machine learning and data mining are applicable and needed in a wide variety of fields ranging from process industry to mobile communications and social networks. Recent spearhead application areas include bioinformatics, computational linguistics, multimodal interfaces, and intelligent information access. The major provides an excellent basis for doctoral studies as well as industrial research and development work. Teaching and supervision for Macadamia students is given by an enthusiastic and experienced group headed by world leaders in this research field. Excellent Macadamia students can continue their studies in the Helsinki Doctoral Education Network in Information and Communication Technology (HICT).

## Learning Outcomes

- 1) The student is able to formalize data analysis problems in terms of the underlying statistical and computational principles
- 2) The student is able to assess suitability of different machine learning methods for solving a particular new problem encountered in industry or academia, and apply the methods to the problem.
- 3) The student can interpret the results of a machine learning algorithm, assess their credibility, and communicate the results with experts of other fields.
- 4) The student can implement common machine learning methods, and design and implement novel algorithms by modifying the existing approaches.
- 5) The student understands the theoretical foundations of the machine learning field to the extent required for being able to follow research in the field

## Content and Structure

The students have to take the eight compulsory courses. In addition, they include courses from the major optional courses list. Also other optional courses may be included per agreement with a professor in charge of the major.

### Major compulsory courses 45 credits

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E3210</a>	Machine Learning: Basic Principles	5	I/1st year
<a href="#">CS-E5710</a>	Bayesian Data Analysis	5	I-II/1st year
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5	II/1st year
<a href="#">CS-E4820</a>	Machine Learning: Advanced Probabilistic Methods	5	III-IV/1st year
<a href="#">CS-E4600</a>	Algorithmic Methods of Data Mining	5	I/1st year
<a href="#">CS-E4830</a>	Kernel Methods in Machine Learning	5	I/2nd year
<a href="#">CS-E4840</a>	Information Visualization	5	IV/1st year
<a href="#">CS-E4870</a>	Research Project in Machine Learning and Data Science	5	I-II/2nd year

### Major optional courses (choose 10-20 credits)

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-E4850</a>	Computer Vision	5	III-IV/1st year
<a href="#">ELEC-E5510</a>	Speech Recognition	5	II/2nd year
<a href="#">ELEC-E5550</a>	Statistical Natural Language Processing	5	III-IV/1st year
<a href="#">CS-E5870</a>	High-Throughput Bioinformatics	5	II/2nd year
<a href="#">CS-E4800</a>	Artificial Intelligence	5	III-IV/1st year
<a href="#">CS-E4003</a>	Special Assignment in Computer Science	1-10	I-V
<a href="#">CS-E4010</a>	Special Course in Machine Learning and Data Science	3-10	I-V
<a href="#">CS-E4860</a>	Special Course in Bioinformatics: Machine Learning in Bioinformatics	3-10	IV-V
<a href="#">CS-E5890</a>	Statistical Genetics and Personalized Medicine	5	IV

Also other optional courses may be included per agreement with a professor in charge of the major.

## Mobile Computing, Services and Security

**Professor in charge:** Antti Ylä-Jääski

**Extent:** Long (55-65 credits) or compact major (40-45 credits). Students taking a compact major take also a minor (20-25 cr). Students taking a long major may include an optional minor in their elective studies.

**Abbreviation:** Mobile

**Code:** SCI3045

**School:** School of Science

### Objectives

Studies in the Mobile Computing, Services and Security major give students a broad understanding of the latest and future technologies for mobile and cloud computing from several perspectives. Students will gain practical engineering knowledge of and theoretical insights into the challenges of network application development, service architectures, secure systems engineering, and mobile and cloud platforms. The graduates are well prepared, for example, for industrial R&D jobs, various expert roles, or doctoral studies at Aalto University and abroad.

### Learning outcomes

- Students learn the necessary software skills, theoretical understanding and system architecture principles to design, analyse and implement distributed, mobile and cloud computing systems,
- and they learn the necessary skills and theoretical understanding to systems security design and analysis.
- Students develop capabilities to both develop mobile computing systems in industrial environment and further progress into higher academic research.

### Structure and content

The program covers topics on mobile and wireless networks, network architecture, network-based services and applications, services business, and secure systems engineering. The studies are closely linked with the research done by the teachers, for example, on the Internet of Things, cloud services, mobile platform security, energy and green ICT, pervasive and ubiquitous computing, and mobility protocols. Special attention is paid to security and privacy issues as they are critical requirements in developing and deploying services in open networks and distributed systems. The teaching methods combine theory with hands-on exercises and software development on mobile devices and cloud platforms. Students also learn writing and presentation skills and to follow the latest research.

### Major compulsory courses (40 credits)

These courses are compulsory, unless already included in the student's previous studies. Students who have studied similar content at another university should contact the professors of the major to discuss their personal study plan.

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-C3170</a>	Web Software Development	5	II-III
<a href="#">CS-C3130</a>	Information Security	5	I
<a href="#">CS-E4005</a>	Methods and Tools for Network Systems	5	I-II
<a href="#">CS-E4130</a>	Computer Networks II - Advanced Features	5	I-II
<a href="#">CS-E4140</a>	Applications and Services in Internet	5	I-II
<a href="#">CS-E4160</a>	Laboratory Works in Networking and Security	5	III-IV
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5	I-II
<a href="#">CS-E4000</a>	Seminar on Computer Science	5	I-II, III-V

### Major optional courses

Choose enough courses from the list below to meet the required number of credits.

CODE	NAME	CREDITS	PERIOD/YEAR
INTERNET AND SERVICES:			
<a href="#">CS-E4170</a>	Mobile Systems Programming	5	III-IV
<a href="#">CS-E4003</a>	Special Assignment on Computer Science	1-10	I-II, III-V
<a href="#">CS-E4180</a>	Internet Technologies for Mobile Computing	5	III-IV
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5	I-II
SECURE SYSTEMS:			
<a href="#">CS-E4300</a>	Network Security	5	II
<a href="#">CS-E4310</a>	Mobile Systems Security	5	III-IV
<a href="#">CS-E4320</a>	Cryptography and Data Security	5	I-II
<a href="#">CS-E4330</a>	Special course in information security	5	I-II, III-IV, V

Other courses on relevant topics may be included by prior agreement of the professors of the major.

# Signal, Speech and Language Processing

**Professor in charge:** Mikko Kurimo

**Professors:** Paavo Alku, Visa Koivunen, Jorma Skyttä, Sergiy Vorobyov, Risto Wichman

**Extent:** long major (60 cr) or compact major (40 cr)

**Abbreviation:** SSLP

**Code:** ELEC3010

**School:** Electrical Engineering

## Objectives

The purpose of the major is to provide the students with basics of either signal processing or speech and language processing and the ability to apply those in various fields of science and technology.

Students focusing in signal processing are given a strong theoretical background of modern signal processing. This means a toolbox of knowledge on signals and systems modelling, representation through transforms, systems optimization and implementation. Some emphasis is on the most recent research priorities in the field of signal processing in domains of data analysis, compression and storage, communications as well as in representation of signals. In addition, students can obtain even deeper understanding of signal processing and adjacent sciences, or apply signal processing in other fields. Interesting applications include radar systems and networks, data transmission, sensing and tracking of objects and spaces, as well as analysis of technical (machine based) and social (human based) networks. The cyber level of the smart power grid is increasingly important for efficient energy distribution and utilization, offering a platform for applying signal processing methodology for solving essential problems of great societal impact.

Students focusing in speech and language processing are provided basics of that field and the ability to apply those in various fields of science and technology. Speech and language processing utilizes signal processing, mathematical modeling and machine learning for statistical language modeling, information retrieval and speech analysis, synthesis, recognition and coding. Applications and research priorities have recently been, for example, speech recognition and synthesis, dictation, subtitling, machine translation, language learning, large-scale video data indexing and retrieval, speech coding and quality improvement in mobile phones and networks as well as in medical research of the human voice.

This major offers excellent opportunities also for postgraduate studies.

## Content and structure

The major offers two different study tracks: signal processing and data science, and speech and language processing. The tracks consist of compulsory part and optional part. Student must follow one of the study tracks. In the major there are two courses common to both tracks.

The major can be completed either as a long (60 cr) or compact (40 cr) major. Students taking a compact major take also a master level minor (20-25 cr). Students taking a long major may include an optional minor in their elective studies.



# Signal, Speech and Language Processing - Signal Processing and Data Science

Code	Name	Credits	Period/Year
<b>Compulsory courses (30 credits):</b>			
<a href="#">ELEC-E0100</a>	Introduction to Master's Studies at Aalto ELEC	0	I-II / 1
<a href="#">CS-E3210</a>	Machine learning: Basic principles	5	I / 1
<a href="#">ELEC-E5410</a>	Signal Processing for Communications	5	I-II / 1
<b>Choose 20 credits:</b>			
<a href="#">CS-E4600</a>	Algorithmic Methods for Data Analysis	5	I / 1
<a href="#">ELEC-E5420</a>	Convex Optimization for Engineers L	5	I-II / 1
<a href="#">ELEC-E5430</a>	Signal Processing for Large Scale Data Analysis L	5	III-IV / 1
<a href="#">ELEC-E5440</a>	Statistical Signal Processing L	5	I-II / 1
<a href="#">ELEC-E5470</a>	Advanced Topics in Statistical Learning L	5	III-IV / 1
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5	II
<b>Optional courses, choose 30 credits (long major) or 10 credits (compact major):</b>			
<b>As optional courses students can choose any courses from the above list of compulsory courses or courses from a specific field of specialization listed below. Courses can be selected either from one field or can be combined from several fields.</b>			
<b>Signal processing:</b>			
<a href="#">ELEC-E5490</a>	Convex Optimization Project L	3	III-IV
<a href="#">ELEC-E5450</a>	Signal Processing Seminar I L V	2-5	I-II
<a href="#">ELEC-E5460</a>	Signal Processing Seminar II L V	2-5	III-IV
<a href="#">ELEC-E5400</a>	Project Work in Signal Processing	1-10	I-V
<b>Pattern Recognition and Machine Learning:</b>			
<a href="#">CS-E4800</a>	Artificial Intelligence	5	III-IV
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks P	5	II
<a href="#">CS-E4820</a>	Machine Learning: Advanced Probabilistic Methods P	5	III-IV
<a href="#">CS-E4830</a>	Kernel Methods in Machine Learning	5	I-II
<a href="#">CS-E4840</a>	Information Visualization	5	IV
<a href="#">CS-E4850</a>	Computer Vision P	5	III-IV
<a href="#">CS-E5870</a>	High-Throughput Bioinformatics P	5	I
<a href="#">ELEC-E5550</a>	Statistical Natural Language Processing P	5	III-IV
<b>Signal Processing in Medical Technology:</b>			
<a href="#">NBE-E4010</a>	Medical Image Analysis L	5	III-V
<a href="#">NBE-E4020</a>	Medical Imaging P	5	III-iV
<a href="#">NBE-E4050</a>	Signal Processing in Biomedical Engineering P	5	I-II even years
<b>Signal Processing in Automation:</b>			
<a href="#">ELEC-E8118</a>	Robotic Vision L	5	III

<a href="#">ELEC-E8119</a>	Robotics: Manipulation, Decision Making and Learning L	5	I-II
<b>Telecommunications and information theory:</b>			
<a href="#">ELEC-C7220</a>	Information Theory	5	II
<a href="#">ELEC-E7129</a>	Wireless Systems	5	I
<a href="#">ELEC-E7210</a>	Communications Theory	5	II
<a href="#">ELEC-E7230</a>	Mobile Communications Systems	5	I
<a href="#">ELEC-E7240</a>	Coding Methods	5	III
<a href="#">MS-E2152</a>	Game Theory	5	I-II
<b>Microelectronics Design:</b>			
<a href="#">ELEC-E3510</a>	Basics of IC Design	5	III
<a href="#">ELEC-E3520</a>	Digital Microelectronics I L	5	III
<a href="#">ELEC-E3540</a>	Digital Microelectronics II L	5	IV-V
<b>Remote Sensing:</b>			
<a href="#">ELEC-E4230</a>	Microwave Earth Observation Instrumentation P	5	
<a href="#">GIS-E1030</a>	Introduction to Spatial Methods	5	II
<a href="#">GIS-E3050</a>	Advanced Remote Sensing Kaukokartoituksen jatkokurssi	5	
<b>Speech and Audio Signal Processing and Acoustics</b>			
<a href="#">ELEC-E5500</a>	Speech Processing	5	I
<a href="#">ELEC-E5510</a>	Speech Recognition	5	II
<a href="#">ELEC-E5520</a>	Speech and Language Processing Methods	2	III-IV
<a href="#">ELEC-E5530</a>	Speech and Language Processing Seminar	3	III-IV
<a href="#">ELEC-E5550</a>	Statistical Natural Language Processing	5	III-IV
<a href="#">ELEC-E5600</a>	Communication Acoustics	5	I
<a href="#">ELEC-E5610</a>	Acoustics and the Physics of Sound	5	II
<a href="#">ELEC-E5620</a>	Audio Signal Processing	5	III-IV
<a href="#">ELEC-E5630</a>	Acoustics and Audio Technology Seminar (varying content)	5	IV-V
<a href="#">ELEC-E5650</a>	Electroacoustics	5	IV-V
<b>Mathematics and Optimization</b>			
<a href="#">MS-E2148</a>	Dynamic Optimization	5	III
<a href="#">MS-E1111</a>	Galois Theory P	5	IV
<a href="#">MS-E2134</a>	Decision making and problem solving	5	I
<a href="#">MS-C2128</a>	Ennustaminen ja aikasarja-analyysi	5	II
<b>Programming and Software projects</b>			
<a href="#">CS-C2130</a>	Software Project 1	5	
<a href="#">CS-C2140</a>	Software Project 2	5	
<a href="#">CS-C3140</a>	Operating Systems	5	
<a href="#">CS-C3150</a>	Software Engineering	5	
<a href="#">CS-C3180</a>	Software Design and Modelling	5	
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5	

<a href="#">CS-E4150</a>	Embedded Systems	5	
<a href="#">CS-E5460</a>	Project in Embedded Systems	5	I-II, III-IV
<a href="#">ELEC-C7310</a>	Application Programming	5	
<a href="#">ELEC-E8001</a>	Embedded Real-Time Systems	5	I-II
<a href="#">ELEC-E8408</a>	Embedded Systems Development	5	III-IV

## Signal, Speech and Language Processing - Speech and Language Processing

Code	Name	Credits	Period/Year
<b>Compulsory courses (30 credits):</b>			
<a href="#">CS-E3210</a>	Machine learning: Basic principles	5	I / 1
<a href="#">ELEC-E0100</a>	Introduction to Master's Studies at Aalto ELEC	0	I-II / 1
<a href="#">ELEC-E5410</a>	Signal Processing for Communications	5	I-II / 1
<a href="#">ELEC-E5500</a>	Speech Processing	5	I-II / 1
<a href="#">ELEC-E5510</a>	Speech Recognition	5	II / 1
<a href="#">ELEC-E5520</a>	Speech and Language Processing Methods	2	III-IV / 1
<a href="#">ELEC-E5530</a>	Speech and Language Processing Seminar V	3-5	III-IV / 1
<a href="#">ELEC-E5550</a>	Statistical Natural Language Processing	5	III-IV / 1
<b>Optional courses, choose 30 credits (long major) or 10 credits (compact major):</b>			
<a href="#">CS-E5710</a>	Bayesian Data Analysis	5	I-II
<a href="#">CS-C3120</a>	Human-computer Interaction	5	I-II
<a href="#">CS-E4810</a>	Machine Learning and Neural Networks	5	II
<a href="#">CS-E4820</a>	Machine Learning: Advanced Probabilistic Methods	5	III-IV
<a href="#">CS-E4830</a>	Kernel Methods in Machine Learning	5	II
<a href="#">CS-E4850</a>	Computer Vision P	5	III-IV
<a href="#">CS-E5790</a>	Computational Science	5	I-II
<a href="#">ELEC-E5420</a>	Convex Optimization for Engineers	5	I-II
<a href="#">ELEC-E5430</a>	Signal Processing for Large Scale Data Analysis	5	III-IV
<a href="#">ELEC-E5440</a>	Statistical Signal Processing	5	I-II
<a href="#">ELEC-E5470</a>	Advanced Topics in Statistical Learning L	5	III-IV
<a href="#">ELEC-E5490</a>	Convex Optimization Project L	3	III-IV
<a href="#">ELEC-E5540</a>	Special assignment in Speech and Language Processing	1-10	I-V
<a href="#">ELEC-E5600</a>	Communication Acoustics	5	I
<a href="#">ELEC-E5620</a>	Audio Signal Processing	5	III-IV
<a href="#">ME-C3100</a>	Computer Graphics	5	I-II
	Kieliteknologian johdantokurssi (HY) (as JOO-studies)		
	Fonetiikan perusteet (HY) (as JOO-studies)		

# Master's Degree Programme in Security and Mobile Computing (NordSecMob)

**Please note that this is a double degree programme implemented through international collaboration which is why its structure may deviate from the regular structure of the Master's Degree Programme in Computer, Communication and Information Sciences.**

<b>Degree(s) awarded</b>	Master of Science (Technology ) from Aalto University Master of Science or similar degree from partner university
<b>Major</b>	Security and Mobile Computing (T3011)

## Contact information

**Programme website:** <http://nordsecmob.aalto.fi/en/>

**Administration:** Study Coordinator Aino Roms

**Programme director:** Prof. Antti Ylä-Jääski

## Programme description

The Nordic countries are very innovative in mobile communications and an industrial and scientific cluster has formed to serve this area. The NordSecMob - Master's Programme in Security and Mobile Computing is based on the research cooperation between the participating universities and it offers in-depth knowledge in the field of data communications, mobile computing and information security.

This Master's programme extends the students computer science skills towards the mobile computing area. The courses in the programme address the modern data communications architecture evolution from several aspects. The students will gain practical knowledge and theoretical insights in the fields of network applications, services, information security and mobile networking. After completion of this programme, the graduates will have a broad knowledge basis of mobile computing and they will be able to design and develop their own solutions for the mobile Internet, having both the practical skills and the capability to follow the scientific research. The Internet technologies form the technical framework of the NordSecMob programme. The key subject areas for both the Internet and mobile networks are applications and services, including service management issues like mobility, quality of service, charging and security. The students are required to both study and create practical implementations based on the current technologies and to learn the emergent trends in the research community. Special attention is paid to the information security, which is a critical issue when developing and deploying services on public networks.

NordSecMob is a full-time Master of Science degree programme with duration of two years. The programme is coordinated by the Aalto University School of Science (AALTO), Department of Computer Science and Engineering. The other four Nordic partner universities are KTH Royal Institute of Technology in Sweden, The Norwegian University of Science and Technology (NTNU), The Technical University of Denmark (DTU) and University of Tartu (UT) in Estonia. The NordSecMob programme gives the students a chance to experience the cultures of two Northern European countries. After completing the two-year programme successfully, the students will be awarded two officially recognized M.Sc. degrees: one from each university where they studied.

The NordSecMob programme graduates are equipped to be employed internationally by both industry and academia, having acquired the necessary skills for various work opportunities including expert role, R&D, research and management positions. This programme gives a solid basis to continue academic career towards the doctoral level; it also provides the students with experience of international R&D environments and enables access to major international networks.

## **Mobility of students**

A joint curriculum is defined for the programme and it involves always two universities. The 120 ECTS credits are divided into two blocks: 1-2 semesters of teaching (30-60 ECTS credits) will be provided by the home university and 1-2 semesters of teaching (30-60 ECTS credits) will be provided by the host university. The student takes courses focusing on advanced topics on the selected area of specialization:

- AALTO: Technical Information Security and Network Services
- KTH: Communications Systems Design
- NTNU: Information Security
- DTU: Reliable Software Systems
- UT: Mathematical Foundations of Cryptography

The first autumn term studies are taken at one of the three home universities: AALTO, KTH or NTNU. The students with the specialization “Reliable Software Systems” transfer from the home university to DTU for the first spring semester and the second autumn semester. Also the students with the specialization “Mathematical Foundations of Cryptography” move from the home university to UT for the first spring and the second autumn semester. The students with other specialization tracks relocate after the first year studies to the other host universities (AALTO, KTH, NTNU) for the second year studies. The programme includes three semesters of courses followed by a fourth research semester (Master's thesis 30 credits) under the supervision and evaluation of both the home and host university.

This two-year NordSecMob programme, encompassing 120 ECTS credits, leads to two officially recognized M.Sc. degrees issued by the home and host university (double degree).

## **Programme sctructure**

30-60 ECTS Home university courses  
30 ECTS Host university courses  
30 ECTS Master's Thesis in joint supervision

## **Language courses**

According to the degree regulations at Aalto University, students must take at least 3 ECTS of foreign language studies for the degree. In NordSecMob, the students have the option to choose between an English course, fulfilling both oral and written requirements (o,w) or at least 3 ECTS of Finnish courses. We recommend the English course [LC-1310](#) Academic Communication for everyone. Taking the Finnish course(s) as part of the degree requires an application for exemption from the foreign language course requirement. Please contact your study coordinator for more information.

## **Objectives of the programme**

Aalto University specialization: Technical Information Security and Network Services

### Professors In charge

T-110

Antti Ylä-Jääski

T-110

Tuomas Aura

As learning outcomes, the students will be able to apply acquired knowledge of the fundamental technologies and design principles of communication networks, the Internet, and mobile systems including applications, services and service management in order to develop new communication network solutions, service platforms, and service architectures. In addition, they will be able to apply the knowledge acquired on common security mechanisms in software systems and communications networks, including their design principles and limitations, in order to perform threat analysis and security requirements specification and to design and implement secure information systems. Furthermore, the students will also be able to compare and combine the above mentioned knowledge in research and development of communication networks and systems.

### Aalto as home university (first year students)

#### First autumn 2016

Focus: Foundational knowledge and skills for becoming an expert in security and mobile computing.

In the first semester, the students build a body of skills and knowledge that puts them on a fast track to becoming specialists in communications security and mobile computing. They will know the fundamental principles and concepts of information security and cryptography, and have an up-to-date picture of the latest wireless and mobile networking and service delivery technologies.

They will have applied this knowledge in hand-on exercises and will have developed advanced software for distributed systems. Through tailored methodology and English language courses, the students will also have systems engineering skills: modeling, simulations, data analysis, as well as writing and presentation skills, which are needed for the rest of the Master's studies.

#### Compulsory courses (23 ECTS)

Code	Course name	Credits
<a href="#">CS-C3130</a>	Information Security	5 ECTS
<a href="#">CS-E4130</a>	Computer Networks II – Advanced Features	5 ECTS
<a href="#">CS-E4320</a>	Cryptography and Data Security	5 ECTS
<a href="#">CS-E4005</a>	Methods and Tools for Network Systems	5 ECTS
	Language course: Compulsory degree requirement, both oral and written requirements*	3 ECTS

(\*) See 'Language courses' above.

#### Optional courses for the autumn term (at least 7 ECTS)

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E4300</a>	Network Security	5 ECTS
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5 ECTS
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5 ECTS
<a href="#">CS-E4140</a>	Applications and Services in Internet	5 ECTS
<a href="#">CS-E4110</a>	Concurrent Programming	5 ECTS
<a href="#">CS-E4560</a>	Parallel and Distributed Systems	5 ECTS

**Total 30 ECTS**

### **First spring 2017**

Focus: Advanced courses in mobile computing, security and services including interactive courses, project works and research assignments.

Building on the foundations laid in the autumn, the students learn advanced topics in areas of their choice and continue to improve their research and hands-on skills. They will have in-depth understanding of some specialist topics in mobility, network services development and communications security. The topics include advanced services in distributed systems, network application frameworks, network services business models and value chains, embedded systems development and latest research in internetworking technologies. The students are able to apply their knowledge and present technical information in written and spoken form.

### **Compulsory courses (10 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E4160</a>	Laboratory Works in Networking and Security	5 ECTS
<a href="#">CS-E4000</a>	Seminar in Computer Science	5 ECTS

### **Optional courses for the spring term (20 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E4250</a>	Network Service Business Models	5 ECTS
<a href="#">CS-E4170</a>	Mobile Systems Programming	5 ECTS
<a href="#">CS-E4003</a>	Special Assignment on Computer Science	
<a href="#">CS-E4002</a>	Special Course on Computer Science	
<a href="#">CS-E4330</a>	Special Course in Information Security	
<a href="#">CS-E4310</a>	Mobile Systems security	5 ECTS
<a href="#">CS-E4180</a>	Internet Technologies for Mobile Computing	5 ECTS
<a href="#">ELEC-E8408</a>	Embedded Systems Development	5 ECTS
<a href="#">LC-98.7011</a>	Finnish 1A	2 ECTS
<a href="#">LC-98.7012</a>	Finnish 1B	• ECTS



Total 30 ECTS

**Total for the whole year: 60 ECTS**

### **Aalto as host university (second year students)**

#### **Second autumn 2016**

Focus: Advanced courses in mobile computing, security, and services including interactive courses, project works and research assignments.

Taking into account their personal specialization, the students learn advanced topics in areas of their choice and continue to improve their research and hands-on skills. They will have an up-to-date picture of the latest wireless and mobile networking and service delivery technologies and in-depth understanding of some specialist topics in mobility, network services development and communications security. The topics include next generation wireless networks, new protocols in computer networks, and the latest research in communications security. The students are able to apply their knowledge and present technical information in written and spoken form.

#### **Compulsory courses (13 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E4130</a>	Computer Networks II – Advanced Features	5 ECTS
<a href="#">CS-E4000</a>	Seminar in Computer Science	5 ECTS
	Language course: Compulsory degree requirement, both oral and written requirements*	3 ECTS

(\* ) See ‘Language courses’ above.

#### **Optional courses (17 ECTS)**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
<a href="#">CS-E4100</a>	Mobile Cloud Computing	5 ECTS
<a href="#">CS-E4300</a>	Network Security	5 ECTS
<a href="#">CS-E4140</a>	Applications and Services in Internet	5 ECTS
<a href="#">CS-E4003</a>	Special Assignment on Computer Science	
<a href="#">CS-E4002</a>	Special Course on Computer Science	
<a href="#">CS-E4330</a>	Special Course in Information Security	
<a href="#">CS-E4005</a>	Methods and Tools for Network Systems	5 ECTS
<a href="#">CS-E4120</a>	Scalable Cloud Computing	5 ECTS
<a href="#">ELEC-A7901</a>	Internet Forum LV	2 ECTS
<a href="#">LC-98.7011</a>	Finnish 1 A	2 ECTS
<a href="#">LC-98.7012</a>	Finnish 1 B	2 ECTS

Total 30 ECTS



**Second spring 2017**

<b>Code</b>	<b>Course name</b>	<b>Credits</b>
	Master's Thesis	30 ECTS

**Total for the whole year: 60 ECTS**

# Software and Service Engineering

**Professor in charge:** Casper Lassenius

**Extent:** Long (55-65 credits) or compact major (40-45 credits). Students taking a compact major take also a minor (20-25 cr). Students taking a long major may include an optional minor in their elective studies.

**Abbreviation:** SSE

**Code:** SCI3043

**School:** School of Science

## Objectives

Digital products and services are crucial to economies, societies and human well-being. For companies and other organizations, they offer exponentially expanding opportunities for new functionality and capabilities beyond traditional product boundaries. Students of Software and Service Engineering learn how to design, develop, and manage digital products and services that create business value and satisfy user needs within modern organizations. Students learn how to tackle wicked, real-world problems taking human, societal and organizational factors into account.

The major has four tracks making it possible to specialize in software engineering, service design and engineering, user-centered design, or enterprise systems.

## Structure and Content

SSE offers both long and compact majors. The following tracks are available:

1. Software Engineering
2. Service Design and Engineering (SDE)
3. User-Centered Design
4. Enterprise Systems

All the students majoring software and service engineering take the major common courses (10 credits). In addition, they take courses according to their study track. It is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CSE-E5695)

## Major common courses 10 credits

<b>CODE</b>	<b>NAME</b>	<b>CREDITS</b>	<b>PERIOD/YEAR</b>
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV

\* If the course have been taken as part of the B.Sc. studies, it can be substituted with any optional courses of the track the student is studying. In the case the student has taken similar course at another institution, the professor should be contacted for discussing possible substitution.

## Software Engineering

**Professor in charge:** Casper Lassenius

**Extent:** Long (55-65 credits) or compact major (40-45 credits). Students taking a compact major also take a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

### Objectives

Software is at the core of most developed economies and organizations. The software engineering track is intended for students who want to become proficient in developing and managing development of software systems and services in real-world organizations, big and small.

The track combines theoretical studies with a large number of practical assignments done both in groups and as individuals, providing opportunities not only to understand but to apply the various methods and tools taught. Many of the assignments are either done for industrial customers representing real-life organizations or based on cases from industry. Many courses use lecturers from industry to provide practical viewpoints to the subjects studied.

Software engineering majors typically work in industry in roles such as Scrum Master, team lead, software architect, project manager, test lead, process engineer, or product owner. Students of software engineering are recommended to take a technical minor in computer science, but the major can also be fruitfully combined with e.g. strategic management, organizational development, or occupational psychology and leadership. The long major gives students the possibility to study software engineering more in-depth, giving the possibility to focus on a specific area of interest. This lays a good foundation for expert roles in industry, or for PhD studies in software engineering.

### Learning outcomes

In the software engineering track, students learn the processes, methods and techniques used in professional software development in organizations and projects of various sizes. Core subjects include various software development activities, such as requirements engineering, design, implementation, testing and deployment, as well as supporting activities including project management, organizational development, and configuration management.

### Software Engineering Long Major (55-65 credits)

The long major in software engineering gives students the opportunity to specialize in software engineering to help become software engineering experts in industry, as well as lays a good foundation for graduate studies. Students of the long major have the possibility to tailor the major personally in collaboration with their supervising professor.

The students take the major common courses and track compulsory courses. In addition, they take courses from the track optional course list. It is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CS-E4920).

**Major common courses (10 credits)**

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV
<a href="#">CS-E4900</a>	User-centred Methods for Product and Service Design	5	I-II

**Track compulsory courses (15-18 credits)**

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-C3180</a>	Software Design and Modelling*	5	I-II
<a href="#">CS-E4910</a>	Software Project 3	5-8	I-V
<a href="#">CS-E5000</a> or <a href="#">CS-E5001</a>	Seminar in Software and Service Engineering or Research Seminar in Software and Service Engineering	5	I-II, III-V

**Track optional courses**

SELECT 20-40 CREDITS FROM THE FOLLOWING

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E4920</a>	Portfolio in Software and Service Engineering	1-5	I-V
<a href="#">CS-E5005</a>	Research Methods in Software and Service Engineering	5	I-II
<a href="#">CS-E4930</a>	Software Processes and Projects	5	IV-V
<a href="#">CS-E4940</a>	Requirements Engineering	5	III-V
<a href="#">CS-E4950</a>	Software Architectures	5	III-IV
<a href="#">CS-E4960</a>	Software Testing and Quality Assurance	5	I-II
<a href="#">CS-E5004</a>	Individual Studies in Software and Service Engineering	1-10	I-V
<a href="#">CS-E5002</a>	Special Course in Software and Service Engineering	1-10	I-V

IN ADDITION, SELECT 0-30 CREDITS FROM THE FOLLOWING

CODE	NAME	CREDITS	PERIOD
<a href="#">TU-E5000</a>	Innovation and project management	5	II
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2	I-II
<a href="#">CS-</a>	Management of a Technology Ventures	5	I-II

[E5110](#)

[TU-C3030](#) Basics in Research and Development Management 3-5 III-IV

[CS-E4970](#) Individual Study in Software Business 2-16 I-V

[TU-E3010](#) Leading as Practice 5 III-V

In addition to the above, courses from the other tracks of the SSE major can be included as optional courses. Also other optional courses can be included per agreement with a professor in charge of the track.

\* If the course has been taken as part of the B.Sc. studies, it can be substituted with any optional courses of the track. In the case the student has taken similar courses at another institution, the professor should be contacted for discussing possible substitutions.

## Software Engineering Compact Major 40-45 credits

The compact major aims at teaching students the main elements of software engineering to give them a sound foundation for future careers in industry.

The students take the major common courses (10 credits) and track compulsory courses (10-13 credits). In addition, they take courses from the track optional courses list and other optional studies. Students taking a compact major must have a minor (20-25 credits). It is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CS-E4920).

### Major common courses (10 credits)

CODE	NAME	CREDITS	PERIOD/YEAR
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV
<a href="#">CS-E4900</a>	User-centred Methods for Product and Service Design	5	I-II

### Track compulsory courses (15-18 credits)

CODE	NAME	CREDITS	CODE
<a href="#">CS-C3180</a>	Software Design and Modelling*	5	I-II
<a href="#">CS-E4910</a>	Software Project 3	5-8	I-V

### Track optional courses

SELECT 20-40 CREDITS FROM THE FOLLOWING

CODE	NAME	CREDITS	PERIOD
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<a href="#">CS-E4920</a>	Portfolio in Software and Service Engineering	1-5	I-V
<a href="#">CS-E5000</a> or <a href="#">CS-E5001</a>	Seminar in Software and Service Engineering or Research Seminar in Software and Service Engineering	5	I-II, III-V
<a href="#">CS-E5005</a>	Research Methods in Software and Service Engineering	5	I-II
<a href="#">CS-E4930</a>	Software Processes and Projects	5	IV-V
<a href="#">CS-E4940</a>	Requirements Engineering	5	III-V
<a href="#">CS-E4950</a>	Software Architectures	5	III-IV
<a href="#">CS-E4960</a>	Software Testing and Quality Assurance	5	I-II
IN ADDITION, SELECT 0-30 CREDITS FROM THE FOLLOWING			
CODE	NAME	CREDITS	PERIOD
<a href="#">TU-22.1500</a>	Innovation and Project Management	5	I-II
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2	I-II
<a href="#">TU-53.1211</a>	Organizational development	4	III-IV
<a href="#">TU-C3030</a>	Basics in Research and Development Management	5	III-IV

In addition to the above, courses from the other tracks of the SSE major can be included as optional courses. Also other optional courses can be included per agreement with a professor in charge of the track.

\* If the course has been taken as part of the B.Sc. studies, it can be substituted with any optional courses of the track. In the case the student has taken similar courses at another institution, the professor should be contacted for discussing possible substitutions.

## User-Centered Design

**Professor in charge:** Marko Nieminen

**Extent:** Long (55-65 credits) or compact major (40-45 credits). Students taking a compact major also take a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

**Abbreviation:** UCD

### Objectives

Digital services, software, and applications form an integral part of modern everyday life both in working surroundings and in leisure time contexts. Software in large government organisations is being used by employees who perform a multitude of tasks. Tiny mobile games are developed for entertaining people. In both cases, users are in a central position for the creation of successful results.

Core contents of the user-centred design track include the conceptual and methodological basis for working with users in different stages of software and service development. A typical characteristic of contemporary software and service design is its multi-disciplinarity. Users and developers with varying backgrounds create novel, innovative, and efficient concepts and realisations in a

collaborative manner. The user-centred methods and tools support these joint design and evaluation activities.

After completing their studies, students often work in technology companies as user interface and interaction designers, UX managers, software developers, and project managers.

## Learning outcomes

In "user-centred design" track students learn concepts, models, methods, procedures, and processes that can be applied in the design and development of systems and services so that the outcomes not only fit users' needs, expectations, and contexts but also deliver excellent user experience. In the real-life-connected study assignments students of user-centred design learn how to analyse user contexts, form user requirements, do interaction design, develop user interfaces, evaluate the usability of a system, and connect these to business goals. Students learn how to use qualitative and quantitative data and results in decision making.

## User-Centered Design Long Major 55-65 credits

The long major in user-centred design gives students the opportunity to become interaction design and user experience experts in industry. The long major lays a proper foundation for doctoral studies in the field. Students of the long major have the possibility to tailor the major personally in collaboration with their supervising professor.

The students take the major common courses and track compulsory courses. In addition, they take courses from the track optional course list. It is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CS-E4920).

### Major common courses (10 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV
<a href="#">CS-E4900</a>	User-centred Methods for Product and Service Design	5	I-II

### Track compulsory courses (20 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E5200</a>	Design Project	10	III-IV
<a href="#">CS-E5210</a>	Usability Evaluation	5	IV-V
<a href="#">CS-E5220</a>	User Interface Construction	5	II

### Track optional courses

SELECT MIN 25 CREDITS FROM THE FOLLOWING

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E4920</a>	Portfolio in Software and Service Engineering	1-5	I-V
<a href="#">CS-</a>	Seminar in Software and Service Engineering	5	I-II, III-

<a href="#">E5000</a>				V
<a href="#">CS-E5001</a>	Research Seminar in Software and Service Engineering	5		I-II, III-V
<a href="#">CS-E4940</a>	Requirements Engineering	5		III-V
<a href="#">CS-E4910</a>	Software Project 3	5-8		I-V
<a href="#">CS-E4200</a>	Emergent User Interfaces	5		III-IV
<a href="#">CS-C2000</a>	Ihminen havaitsijana	5		III-IV
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5		II
<a href="#">ELEC-E7861</a>	Research Project in Human-Computer Interaction	5		III-IV
<a href="#">TU-C1010</a>	Ihminen ryhmässä	5		I-II
<a href="#">CS-E5002</a>	Special Course in Software and Service Engineering	1-10		I-V

In addition to the above, courses from the other tracks of the SSE major can be included as optional courses. Also other optional courses can be included per agreement with a professor in charge of the track.

\* If any of these courses have been taken as part of the B.Sc. studies, they can be substituted with any elective courses of the track. In the case the student has taken similar courses at another institution, the professor should be contacted for discussing possible substitutions.

### **User-Centered Design Compact Major 40-45 credits**

The students take the major common courses (10 cr) and track compulsory courses (10 cr). In addition, they take courses from the track optional courses list and other optional studies. Students taking a compact major must have a minor (20-25 credits). It is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CS-E4920).

#### **Major common courses (10 credits)**

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV
<a href="#">CS-E4900</a>	User-centred Methods for Product and Service Design	5	I-II

#### **Track compulsory courses (10 credits)**

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E5210</a>	Usability Evaluation	5	IV-V
<a href="#">CS-E5220</a>	User Interface Construction	5	II

## Track optional courses

SELECT MIN 20-25 CREDITS FROM THE FOLLOWING

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E4920</a>	Portfolio in Software and Service Engineering	1-5	I-V
<a href="#">CS-E5000</a>	Seminar in Software and Service Engineering	5	I-V
<a href="#">CS-E5001</a>	Research Seminar in Software and Service Engineering	5	I-II, III-V
<a href="#">CS-E5200</a>	Design Project	10	III-V
<a href="#">CS-C2000</a>	Ihminen havaitsijana	5	III-IV
<a href="#">ELEC-E7851</a>	Computational User Interface Design	5	II
<a href="#">TU-C1010</a>	Ihminen ryhmässä	5	I-II
<a href="#">CS-E5002</a>	Special Course in Software and Service Engineering	1-10	I-V

\* If any of these courses have been taken as part of the B.Sc. studies, they can be substituted with any elective courses of the track. In the case the student has taken similar courses at another institution, the professor should be contacted for discussing possible substitutions.

## Service Design and Engineering

**Professor in charge:** Marjo Kauppinen

**Extent:** Compact major (40-45 credits) and Aalto Service Minor (20 credits). Students who want to take also an optional minor may include it in their elective studies.

**Abbreviation:** SDE

### Objectives

The focus of the Service Design and Engineering track (SDE) is on the role of IT as an enabler of new types of services and how these new services should be designed and implemented. Students learn how to combine service design and software engineering to create effective and productive development processes matching the development and business needs of the organizations involved.

The starting point for SDE is the needs of the service user. SDE students learn to analyze those needs and design new digital services to meet those needs. The services can be commercial or public, combining both IT and non-IT components to create just the right overall user experience.

### Learning outcomes

Students are able to

1. discover and analyse customer and user needs
2. combine design techniques from software engineering, service design and user-centred design, and apply them in practice
3. tailor an efficient design process for the needs of a company and projects
4. design and implement digital services that create customer and business value
5. create novel and innovative service concepts in multidisciplinary teams
6. critically evaluate strengths and weaknesses of service concepts and digital services



7. build up strong conceptual foundation and well-structured knowledge base for lifelong learning

## Content and structure

The SDE track consists of a compact major and the Aalto Service Minor. In addition to the major common courses, the Design Project is the only compulsory course of the SDE track, but it is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CS-E4920).

With the elective studies students can orient themselves towards a number of roles, for instance user research and service design or developing and improving development processes. The student can choose between all SSE courses and design a personal study program. The table lists some example courses.

Students taking the SDE and wanting to focus on software business and entrepreneurship are recommended to take the Aalto Ventures Program Minor as part of their elective studies.

### Major common courses (10 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV
<a href="#">CS-E4900</a>	User-centred Methods for Product and Service Design	5	II

### Track compulsory course (10 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E5200</a>	Design Project	10	III-IV

### Track optional courses (20-25 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E4920</a>	Portfolio in Software and Service Engineering	1-5	I-V
<a href="#">CS-E5000</a>	Seminar in Software and Service Engineering	5	I-II, III-V
<a href="#">CS-E5001</a>	Research Seminar in Software and Service Engineering	5	I-II, III-V
<a href="#">CS-C3180</a>	Software Design and Modeling*	5	I-II
<a href="#">CS-E4930</a>	Software Processes and Projects	5	IV-V
<a href="#">CS-E4940</a>	Requirements Engineering	5	III-V
<a href="#">CS-E4950</a>	Software Architectures	5	III-IV
<a href="#">CS-</a>	Software Testing and Quality Assurance	5	I-II

[E4960](#)

[CS-E5005](#) Research Methods in Software and Service Engineering 5 I-II

In addition to the above, courses from the other tracks of the SSE major can be included as optional courses. Also other optional courses can be included per agreement with a professor in charge of the track.

### **Aalto Service Minor**

CODE	NAME	CREDITS	PERIOD
<a href="#">TU-E2000</a>	Aalto Introduction to Services P	6	I
Core courses (choose at least two)			
<a href="#">TU-E2010</a>	Industrial Service Operations	3-6	III
<a href="#">MUO-E3008</a>	Designing for Services	5 or 10	III
<a href="#">CS-E4900</a>	User-Centered Methods for Product and Service Design	5	I-II
<a href="#">CS-E5310</a>	ICT Enabled Service Business and Innovation	5	I-II
<a href="#">37E00100</a>	Information Economy	6	IV
<a href="#">37E08000</a>	Service Business Models	6	IV
<a href="#">TU-E2010</a>	Industrial Service Operations	3-6	III

If necessary, choose from the courses listed below to reach total credit requirement. The courses listed below can be included in the minor without separate approval (NOTE: acceptance to Aalto Service Minor does not guarantee that you will be accepted to these courses):

<a href="#">37E01500</a>	Project Management and Consulting Practice	6	II
<a href="#">37E4400</a>	Critical Issues in Information Systems Research (varying content)	6	V
<a href="#">TU-E2110</a>	Innovation in Operations and Services	3-5	III-IV
<a href="#">TU-E3120</a>	Human Resources in Service Operations	5	I-II
<a href="#">23C550</a>	Services Marketing	6	III

\* If any of these courses have been taken as part of the B.Sc. studies, they can be substituted with any elective courses of the track. In the case the student has taken similar courses at another institution, the professor should be contacted for discussing possible substitutions.

## **Enterprise Systems**

**Professor in charge:** Martti Mäntylä

**Extent:** Long or compact major (40-65 credits). Students taking a compact major take also a minor (20-25 credits). Students taking a long major may include an optional minor in their elective studies.

### **Objectives**

For most companies and organizations, developing and managing information systems has become increasingly critical for how the companies create and capture value, how they work with partners

and users, and how they secure competitive advantage. The Enterprise Systems track provides its students the knowledge, competences, and skills they will need to act successfully in the industry and society to tackle these challenges and opportunities.

## Learning outcomes

After completing the track, the students should be able to understand the opportunities of digitalization in industrial applications and related domains and to turn these opportunities to actual business value by defining, creating, deploying, and managing relevant information systems. They will have the skills needed to work effectively in multidisciplinary teams including business and technology experts.

## Structure

Students are expected to take the major common courses and track compulsory courses. In addition, they take courses from the track optional course list. It is strongly recommended that students also participate in the Portfolio course in Software and Service Engineering (CS-E4920).

### Framtidens industriföretag, FIF, 60 credits

FIF is a Nordic interdisciplinary programme for engineering students. Students who have chosen the Enterprise Systems track as their long major can apply to take part in FIF. The application round is organised annually in March/April.

In addition to the the major common courses and track compulsory courses, FIF students include FIF courses in their Track optional courses and in the Elective Studies. Course choices are confirmed in the student's personal study plan (HOPS) after consultation with the professor. For more information on FIF please see <http://fif.aalto.fi/sv/>.

### Major common courses (10 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-C3150</a>	Software Engineering *	5	I-II, III-IV
<a href="#">CS-E4900</a>	User-centred Methods for Product and Service Design	5	I-II

### Track compulsory courses (15 credits)

CODE	NAME	CREDITS	PERIOD
<a href="#">CS-E5300</a>	Enterprise Systems Architecture *	5	I
<a href="#">CS-E5310</a>	ICT Enabled Service Business and Innovation	5	I-II
<a href="#">CS-E5320</a>	Seminar on Enterprise Information Systems	5	IV

### Track optional courses

CODE	NAME	CREDITS	PERIOD
SELECT 15-30 CREDITS FROM THE FOLLOWING			
<a href="#">CS-E4920</a>	Portfolio in Software and Service Engineering	1-5	I-V
<a href="#">CS-E5380</a>	Special Assignment on Enterprise Information Systems	3-10	I-V

<a href="#">CS-E5000</a>	Seminar in Software and Service Engineering	5	I-II, III-V
<a href="#">CS-E5001</a>	Research Seminar in Software and Service Engineering	5	I-II, III-V
<a href="#">CS-E5330</a>	IT Governance	5	II
<a href="#">CS-E5340</a>	Introduction to Industrial Internet	5	IV
<a href="#">CS-E5350</a>	Industrial Internet Project	5-10	I-V
<a href="#">CS-E5360</a>	Systems of Systems	5	V
<a href="#">CS-E5370</a>	Law in Digital Society	5-6	IV
<a href="#">CS-E5390</a>	Seminar on Law and Technology	3-6	IV-V
<a href="#">CS-E5400</a>	IS Procurement and Portfolio Management	4-6	V
<a href="#">CS-E4950</a>	Software Architectures *	5	III-V
<a href="#">CS-E4940</a>	Requirements Engineering *	5	III-V
<a href="#">CS-E4930</a>	Software Processes and Projects	5	IV-V
<a href="#">57E00500</a>	Capstone: Business Intelligence	6	I
IN ADDITION, SELECT 15-30 CREDITS FROM THE FOLLOWING (LONG MAJOR)			
<a href="#">CS-E5005</a>	Research Methods in Software and Service Engineering	3-5	I-II
<a href="#">CS-E5100</a>	Introduction to IT Business and Venturing	2	I-II
<a href="#">CS-E5110</a>	Management of a Technology Venture	6	II
<a href="#">CS-E5410</a>	Technology Entrepreneurship Seminar	4	IV
<a href="#">TU-E1150</a>	Managerial Economics	5	III
<a href="#">TU-E1020</a>	Strategies for Growth and Renewal	3	III-IV
<a href="#">TU-E1120</a>	Strategic Management of Technology and Innovation	5	III-V

\* If any of these courses have been taken as part of the B.Sc. studies, they can be substituted with any elective courses of the track. In the case the student has taken similar courses at another institution, the professor should be contacted for discussing possible substitutions.