UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master IT-Security 2019

Version from 1. April 2025

Applied computer science

Theoretical computer science

technical computer science

Module part

IT-Security

Elective Computer Science

IT Security and Privacy

IT Safety and Reliability

CS4130-KP06, CS4130 - Information Systems (InfoSys)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (basic module), Applied computer science, 1st or 2nd semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master IT-Security 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), Applied computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field software systems engineering, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Applied computer science, 1st or 2nd semester

Classes and lectures:

- Information Systems (lecture, 2 SWS)
- Information Systems (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Motivation of knowledge graphs and their relationship to the Semantic Web
- Overview over the W3C Semantic Web family of languages
- Comparison between and the interaction of knowledge graphs and generative artificial intelligence such as large language models
- Graph Neural Networks and their applications for tasks of knowledge graphs

Qualification-goals/Competencies:

- Knowledge: Students acquire an overview of knowledge graphs and the Semantic Web as well as generative artificial intelligence such as large language models and graph neural networks.
- Skills: Students can assess the possibilities and limitations of knowledge graphs and the Semantic Web. They can estimate the consequences of the Semantic Web approach for data modeling, data administration and processing and for applications. They can develop Semantic Web applications. They can use generative artificial intelligence such as large language models and graph neural networks to solve tasks for and in addition to knowledge graphs. They can discuss open research questions in the area of knowledge graphs and the semantic web as well as in comparison to generative artificial intelligence and graph neural networks.
- Social skills and independence: Students work in groups to complete exercises and small projects. Students' independent practical work is encouraged through exercises, some of them directly on the computer.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Sven Groppe

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- M. Kejriwal, C. Knoblock: Knowledge graphs - MIT Press, 2021
- S. Groppe: Data Management and Query Processing in Semantic Web Databases - Springer, 2011
- W. L. Hamilton: Graph Representation Learning. In Synthesis Lectures on Artificial Intelligence and Machine Learning - Springer International Publishing, 2020
- D. Jurafsky, J. H. Martin: Speech and language processing - Upper Saddle River, NJ: Pearson, 2008
- D. Foster: Generative deep learning - Sebastopol, CA: O Reilly Media, 2023

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester

Module Exam(s):
- CS4130-L1: Information Systems, written exam or oral exam, 100% of module grade

Previous name: Web Based Information Systems

CS4150-KP06, CS4150SJ14 - Distributed Systems (VertSys14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization SSE, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (basic module), Applied computer science, 1st or 2nd semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master IT-Security 2019 (basic module), Applied computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), ehealth / infomatics, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), Applied computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field software systems engineering, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Applied computer science, 1st or 2nd semester

Classes and lectures:

- Distributed Systems (lecture, 2 SWS)
- Distributed Systems (exercise, 2 SWS)

Workload:

- 60 Hours in-classroom work
- 60 Hours private studies
- 40 Hours e-learning
- 20 Hours exam preparation

Contents of teaching:

- Introduction and motivation
- Protocols and layered models
- Message representations
- Realization of network services
- Communication mechanisms
- Addresses, names and directory services
- Synchronisation
- Replication and consistency
- Fault tolerance
- Distributed transactions
- Security

Qualification-goals/Competencies:

- The participants will accquire a deep understanding for problems to be solved in distributed systems, such as synchronization, error handling, naming etc.
- They know the most important services in distributed systems such as name service, distributed file systems etc.
- They are able to program simple distributed applications and systems themselves.
- They know the most important algorithms in distributed systems, for instance for time synchronization, for leader election, or for mutual exclsuion.
- They have a good feeling for when it makes sense to use distributed instead of centralized systems.
- They have a good feeling for what kind of solutions could best be used for what kind of problems in distributed Internet applications.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics

- Prof. Dr. Stefan Fischer
- Dr. rer. nat. Florian-Lennert Lau

Literature:

- A. Tanenbaum, M. van Steen: Distributed Systems: Principles and Paradigms - Prentice Hall 2006
- G. Coulouris, J. Dollimore, T. Kindberg, G. Blair: Distributed Systems - Concepts and Design - Addison Wesley 2012

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- None

Module Exam(s):
- CS4150-L1 Distributed Systems, written exam, 90min, 100% of module grade.

CS4000-KP06, CS4000SJ14 - Algorithmics (ALG14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (basic module), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), Theoretical computer science, 1st or 2nd semester
- Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Theoretical computer science, 1st or 2nd semester

Classes and lectures:

- Algorithmics (lecture, 2 SWS)
- Algorithmics (exercise, 2 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- complexity analysis of algorithmic problems
- discrete optimization problems, linear programming
- satisfiability and constraint satisfaction problems
- randomized algorithms
- approximation algorithms and heuristics
- algorithms for algebraic problems

Qualification-goals/Competencies:

- The students can model real problems in an algorithmic manner.
- They can apply basic algorithmic techniques with full command.
- They can analyze algorithms, in particular with respect to corrrectness and complexity.
- They can design efficient algorithms for complex problems.

Grading through:

- written exam

Requires:

- Theoretical Computer Science (CS2000-KP08, CS2000)
- Algorithm Design (CS3000-KP04, CS3000)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science

- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. rer. nat. Till Tantau
- Prof. Dr. Maciej Liskiewicz

Literature:

- Aho, Hopcroft, Ullman: Design and Analysis of Computer Algorithms - Addison Wesley, 1978
- Cormen, Leiserson, Rivest, Stein: Introduction to Algorithms - The MIT Press, 2009
- Mitzenmacher, Upfal: Probability and Computing - Cambridge University Press, 2005
- Kreher, Stinson: Combinatorial Algorithms - CRC Press, 1999
- Williamson, Shmoys: The Design of Approximation Algorithms - Cambridge University Press, 2011

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competencies of the modules listed under

CS4020-KP06, CS4020SJ14 - Specification and Modelling (SpezMod14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, 3rd semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (basic module), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), Theoretical computer science, 1st or 2nd semester
- Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 2nd or 3rd semester
- Master Computer Science 2014 (basic module), Theoretical computer science, 1st or 2nd semester

Classes and lectures:

- Specification and Modelling (lecture, 2 SWS)
- Specification and Modelling (exercise, 2 SWS)

Workload:

- 80 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation
- 20 Hours work on project

Contents of teaching:

- Introduction to modelling and specification
- Modelling concepts (data, streams, traces, diagrams, tables)
- Modelling software components (state, behaviour, structure, interface)
- Modelling concurrency
- Algebraic specification
- Composing, refining, analysing and transforming specifications and models
- Specification languages and tools for specification and modelling

Qualification-goals/Competencies:

- The students can argue on the importance of specifications and models for software development.
- They can characterize, apply, adapt and extent important specification and modelling techniques.
- They can model and specify simple software/hardware system in an adequate way.
- They can describe a system from different views and on different levels of abstraction.
- They can apply specifications and modelsin software development.
- They can analyse specifications and models.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Dr. Annette Stümpel
- Prof. Dr. Martin Leucker

Literature:

- V.S. Alagar, K. Periyasamy: Specification of Software Systems - Springer 2013
- M. Broy, K. Stølen: Specification and Development of Interactive Systems - Springer 2001
- J. Loeckx, H.-D. Ehrich, M. Wolf: Specification of Abstract Data Types - John Wiley & Sons 1997
- D. Bjorner: Software Enginneering 1-3 - Springer 2006
- U. Kastens, H. Kleine Büning: Modellierung - Grundlagen und formale Methoden - Hanser 2005

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Examination(s):
- CS4020-L1: Specification and Modeling, written exam, 90min, 100% of the module grade.

CS4160-KP06, CS4160SJ14 - Real-Time Systems (Echtzeit14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), technical computer science, 1st or 2nd semester
- Master IT-Security 2019 (basic module), technical computer science, 1st or 2nd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, 1st semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), specific, 1st or 2nd semester
- Master Computer Science 2014 (basic module), technical computer science, 1st or 2nd semester

Classes and lectures:

- Real-Time Systems (lecture, 2 SWS)
- Real-Time Systems (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Real-time processing (definitions, requirements)
- Process automation systems
- Real-time programming
- Process connectivity and networking
- Modelling of discrete event systems (automata, state charts)
- Modelling of continuous systems (differential equations, Laplace transformation)
- Application of design tools (Matlab/Simulink, Stateflow)

Qualification-goals/Competencies:

- The students are able to describe the fundamental problems of real-time processing.
- They are able to explain real-time computer systems for process automation, in particular SPS.
- They are able to program real-time systems in the IEC languages.
- They are able to elucidate process interfaces and real-time bus system.
- They are able to model, analyze and implement event discrete systems, in particular process control systems.
- They are able to model, analyze and implement continuous systems, in particular feedback control systems.
- They are able to make use of design tools for real-time systems.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- R. C. Dorf, R. H. Bishop: Modern Control Systems - Prentice Hall 2010
- L. Litz: Grundlagen der Automatisierungstechnik - Oldenbourg 2012
- M. Seitz: Speicherprogrammierbare Steuerungen - Fachbuchverlag Leipzig 2012
- H. Wörn, U. Brinkschulte: Echtzeitsysteme - Berlin: Springer 2005
- S. Zacher, M. Reuter: Regelungstechnik für Ingenieure - Springer-Vieweg 2014

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS4160-L1: Real-Time Systems, written exam, 90min, 100% of the module grade

CS4170-KP06, CS4170SJ14 - Parallel Computer Systems (ParaRSys14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Certificate in Artificial Intelligence (compulsory), Artificial Intelligence, 1st semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), technical computer science, 1st or 2nd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester
- Master IT-Security 2019 (basic module), technical computer science, 1st or 2nd semester
- Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (basic module), specific, 1st or 2nd semester
- Master Computer Science 2014 (basic module), technical computer science, 1st or 2nd semester

Classes and lectures:

- Parallel Computer Systems (lecture, 2 SWS)
- Parallel Computer Systems (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Motivation and limitations for parallel processing
- Parallel computing models
- Taxonomy of parallel computers
- Multi/manycore-systems
- Graphic Processing Units (GPUs)
- OpenCL
- Specification languages
- Hardware architectures
- System management of many-core systems

Qualification-goals/Competencies:

- Students are able to characterize different parallel computing architectures.
- They are able to explain models of parallel computing.
- They are able to make use of common programming interfaces for parallel computing systems.
- They are able to judge which kind of parallel computing system is best suited for a dedicated problem and how many cores should be used.
- They are able to evaluate the pros and cons of different hardware architectures.
- They are able to write programs for parallel computing systems under considerations of the underlying hardware architecture.
- They are able to compare methods for dynamic voltage and frequency scaling (DVFS) for manycore systems.

Grading through:

- written exam

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- G. Bengel, C. Baun, M. Kunze, K. U. Stucky: Masterkurs Parallele und Verteilte Systeme - Vieweg + Teubner, 2008
- M. Dubois, M. Annavaram, P. Stenström: Parallel Computer Organization and Design - University Press 2012
- B. R. Gaster, L. Howes, D. R. Kaeli, P. Mistry, D. Schaa: Heterogeneous Computing with OpenCL - Elsevier/Morgan Kaufman 2013
- B. Wilkinson; M. Allen: Parallel Programming - Englewood Cliffs: Pearson 2005
- J. Jeffers, J. Reinders: Intel Xeon Phi Coprozessor High-Performance Programming - Elsevier/Morgan Kaufman 2013

- D. A. Patterson, J. L. Hennessy: Computer Organization and Design - Morgan Kaufmann, 2013

Language:

- offered only in German

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS4170-L1: Parallel Computer Systems, oral exam, 100% of the module grade

CS3110 T - Module part: Computer-Aided Design of Digital Circuits (SchaltEnta)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester

Classes and lectures:

- Computer-Aided Design of Digital Circuits (lecture, 2 SWS)
- Computer-Aided Design of Digital Circuits (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Abstraction levels in circuit design
- Design cycle and design strategies
- FPGA architectures
- Introduction of the hardware description language VHDL
- Design of standard components in VHDL
- Circuit design at different abstraction levels
- Circuit design for synthesis
- VHDL simulation cycle
- VHDL circuit design for FPGAs
- Designing Testbenches
- High-Level-Synthesis

Qualification-goals/Competencies:

- Based on a non-formal description of a digital system, students are able to design digital circuits using VHDL
- They are able to simulate and test VHDL descriptions
- They are able to explain the internal structures of FPGAs
- They are able to determine which VHDL construct will result in which circuit structure
- They are able to explain the VHDL simulation cycle
- They are able to write synthesizable VHDL code

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel, R. Bartholomä: Entwurf von digitalen Schaltungen und Systemen mit HDLs und FPGAs - Oldenbour Verlag 2009
- C.Maxfield: The Design Warrior's Guide to FPGAs - Newnes 2004

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

CS4140 T - Module part: Mobile and Distributed Databases (MVDBa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Mobile und verteilte Datenbanken (lecture, 2 SWS)
- Mobile und verteilte Datenbanken (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- The contents of the lecture covers query processing, transactions and replication in
- - centralised database management systems
- - parallel database management systems
- - distributed database management systems
- - mobile database management systems

Qualification-goals/Competencies:

- Students can explain the differences between centralised, parallel, distributed and mobile database management systems.
- They can judge about the practical suitability of different synchronization approaches for distributed and mobile transactions for a given problem.
- They can apply approaches for distributed and mobile query processing.
- They can choose suitable replication approaches for a given application and justify their choices.
- They can recognize and deal with the special difficulties and sources of error in distributed and mobile environments.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- A. Kemper, A. Eickler: Datenbanksysteme - 2006
- T. Conolly, C. Begg: Database Systems - A Practical Approach to Design, Implementation, and Management - Addison-Wesley 2005
- E. Rahm: Mehrrechner-Datenbanksysteme - Addison-Wesley 1994
- P. Dadam: Verteilte Datenbanken und Client/Server Systeme - Springer 1996
- H. Höpfner, C. Türker, B. König-Ries: Mobile Datenbanken und Informationssysteme - dpunkt.verlag 2005
- B. Mutschler, G. Specht: Mobile Datenbanksysteme - Springer 2004
- V. Kumar: Mobile Database Systems - Wiley-Interscience 2006

Language:

- offered only in German

Notes:

(Is equal to CS4140)
(Is module part of CS4508)

Entry requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS4151 T - Module part: Architectures for Distributed Applications (SVAa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Architectures for Distributed Applications (lecture, 2 SWS)
- Architectures for Distributed Applications (exercise, 1 SWS)

Workload:

- 45 Hours in-classroom work
- 45 Hours private studies
- 30 Hours exam preparation

Contents of teaching:

- Motivation
- Software Architectures
- Basics: HTTP, XML & Co
- N-Tier Applications
- Service-Oriented and Event-Driven Architectures (SOA and EDA)
- Web-Oriented Architectures (Web 2.0)
- Overlay Networks
- Peer-to-Peer
- Grid and Cloud Computing
- Internet of Things

Qualification-goals/Competencies:

- The students are able to name the most important archiectures for distributed systems, explain them, and compare them to each other.
- For each architecture, they know the most prominent and important implementation platforms and basically know how to use them.
- For a given problem, they can analyze which architecture is best suited to solve it, and they can design a plan for the solution's realization.

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr.-Ing Horst Hellbrück

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing Horst Hellbrück

Literature:

- J. Dunkel, A. Eberhart, S. Fischer, C. Kleiner, A. Koschel: Systemarchitekturen für verteilte Anwendungen - Hanser-Verlag 2008
- I. Melzer et.al.: Service-Orientierte Architekturen mit Web Services - Spektrum-Verlag 2010

Language:

- offered only in German

Notes:

IMPORTANT: No longer takes place as a module part of CS4509. Please now pay attention to the modules CS4151 and CS4517!

(Was module part of CS4509)
(Is equal to CS4151)
(Share of telematics in everything is 100%)

Entry requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS4220 T - Module part: Pattern Recognition (MEa)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2014 (module part), advanced curriculum, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st semester
- Master Computer Science 2014 (Module part of a compulsory module), specialization field robotics and automation, Arbitrary semester

Classes and lectures:

- Pattern Recognition (lecture, 2 SWS)
- Pattern Recognition (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction to probability theory
- Principles of feature extraction and pattern recognition
- Bayes decision theory
- Discriminance functions
- Neyman-Pearson test
- Receiver Operating Characteristic
- Parametric and nonparametric density estimation
- kNN classifiers
- Linear classifiers
- Support vector machines and kernel trick
- Random Forest
- Neural Nets
- Feature reduction and feature transforms
- Validation of classifiers
- Selected application scenarios: acoustic scene classification for the selection of hearing-aid algorithms, acoustic event recognition, attention classification based on EEG data, speaker and emotion recognition

Qualification-goals/Competencies:

- Students are able to describe the main elements of feature extraction and pattern recognition.
- They are able to explain the basic elements of statistical modeling.
- They are able to use feature extraction, feature reduction and pattern classification techniques in practice.

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr.-Ing. Alfred Mertins

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Alfred Mertins

Literature:

- R. O. Duda, P. E. Hart, D. G. Storck: Pattern Classification - New York: Wiley

Language:

- offered only in German

Notes:

Admission requirements for the module:
- None

Admission requirements for the examination:
- Successful completion of the exercises during the semester (at least 50% of the achievable points).

Module Exam:
- CS4220-L1: Pattern Recognition, written exam, 90 min, 100% of module grade.

(Is equal to CS4220SJ14)
(Is module part of CS4510, CS4290, CS5274-KP08)

CS4405 T - Module part: NeuroInformatics (NeuroInfa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Medical Informatics 2019 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Medical Informatics 2014 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 2nd semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- NeuroInformatics (lecture, 2 SWS)
- NeuroInformatics (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- The human brain and abstract neuron models
- Learning with a single neuron:* Perceptrons* Max-Margin Classification* LDA and logistic Regression
- Network architectures:* Hopfield-Networks* Multilayer-Perceptrons* Deep Learning
- Unxupervised Learning:* k-means, Neural Gas and SOMs* PCA & ICA* Sparse Coding

Qualification-goals/Competencies:

- The students are able to understand the principle function of a single neuron and the brain as a whole.
- They know abstract neuronal models and they are able to name practical applications for the different variants.
- They are able to derive a learning rule from a given error function.
- They are able to apply (and implement) the proposed learning rules and approaches to solve unknown practical problems.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr. rer. nat. Thomas Martinetz

Literature:

- S. Haykin: Neural Networks - London: Prentice Hall, 1999
- J. Hertz, A. Krogh, R. Palmer: Introduction to the Theory of Neural Computation - Addison Wesley, 1991
- T. Kohonen: Self-Organizing Maps - Berlin: Springer, 1995
- H. Ritter, T. Martinetz, K. Schulten: Neuronale Netze: Eine Einführung in die Neuroinformatik selbstorganisierender Netzwerke - Bonn: Addison Wesley, 1991

Language:

- offered only in German

Notes:

Examination prerequisites can be defined at the beginning of the semester. If prerequisite courses are defined, they must have been completed and positively evaluated before the first examination.

(Is module part of CS4410, CS4511)
(Is equal to CS4405)

Admission requirements for the module:
- None

Admission requirements for the examination:
- Successful completion of exercises during the semester.

Translated with www.DeepL.com/Translator (free version)

CS4670 T - Module part: Ambient Computing (AmbCompa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Ambient Computing (lecture, 3 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Current paradigms in computer technology
- Smart components
- Software architectures
- Context-sensitive systems
- Ambient Intelligence
- Interactive ambient media systems
- Ambient Computing Applications (AAL)
- Ethical, Legal and Social Implications (ELSI).

Qualification-goals/Competencies:

- The students are able to evaluate possibilities, concepts and challenges of Ambient Systems
- They have an overview about current technologies and systems for developing Ambient Systems
- They are able to follow and judge state-of-the-art research in the area of Ambient Computing

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing. Andreas Schrader

Literature:

- John Krumm: Ubiquitous Computing Fundamentals - CRC Press, 2009
- Stefan Poslad: Ubiquitous Computing: Smart Devices, Environments and Interactions - Wiley, 2009
- Uwe Hansman et al: Pervasive Computing - Springer, 2003

Language:

- English, except in case of only German-speaking participants

Notes:

(Is part of the module CS4503-KP12)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS5131 T - Module part: Web-Mining Agents (WebMininga)

Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	8

Course of study, specific field and term:

- Certificate in Artificial Intelligence (Module part of a compulsory module), Module part, 1st semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Web-Mining Agents (lecture, 4 SWS)
- Web-Mining Agents (exercise, 1 SWS)
- Web-Mining Agents (practical course, 1 SWS)

Workload:

- 120 Hours private studies
- 90 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Probabilities and generative models for discrete data
- Gaussian models, Bayesian and frequentist statistics, regression,
- Probabilistic graphical models (e.g., Bayesian networks), learning parameters and structures of probabilistic graphical models (BME, MAP, ML, EM algorithm), probabilistic classification, probabilistic relational models
- Probabilistic reasoning over time (dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, hidden Markov models, Kalman filters, exact inferences and approximations, learning dynamic Bayesian networks)
- Structural Causal Networks (Intervention, instrumental Variables, counterfactuals)
- Mixture models, latent linear models (LDA, LSI, PCA), sparse linear models,
- Decision making under uncertainty (utility theory, decision networks, value of information, sequential decision problems, value iteration, policy iteration, MDPs, decision-theoretic agents, POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks)
- Game theory, decisions with multiple agents (Nash equilibrium, Bayes-Nash equilibrium), social choice (voting, preferences, paradoxes, Arrow's Theorem, mechanism design (controlled autonomy), rules of encounter
- Building and exchanging symbolic annotations for web data (from named entity recognition to discourse representations)
- Building and exchanging symbolic annotations for web data (from named entity recognition to discourse representations)
- Information association, retrieval, query answering and recommendation

Qualification-goals/Competencies:

- Knowledge:Students can explain the agent abstraction, define web mining of rational behavior, and give details about the design of mining agents (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques.Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data . For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for reinforcement learning can also be explained by students.
- Skills:Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply Bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states, e.g., Nash

equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results.Students derive decision trees and, in turn, propositional rule sets from static data as well and temporal or streaming data. Students present and apply the basic idea of first-order inductive leaning. They apply the BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They also know how to carry out Gaussian mixture learning. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the different goals of those techniques.

- Social competence: Students work in groups in order to solve small exercise and project assignments and present them in short talks in the plenum. In the associated project lab the students the develop a larger project using up-to-date programing languages and software tools for data science applications.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Information Systems
- Prof. Dr. rer. nat. habil. Ralf Möller
- PD Dr. Özgür Özçep

Literature:

- M. Hall, I. Witten and E. Frank: Data Mining: Practical Machine Learning Tools and Techniques - Morgan Kaufmann, 2011
- D. Koller, N. Friedman: Probabilistic Graphical Models: Principles and Techniques - MIT Press, 2009
- K. Murphy: Machine Learning: A Probabilistic Perspective - MIT Press, 2012
- S. Russel, P. Norvig: Artificial Intelligence: A Modern Approach - Pearson Education, 2010
- Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations - Cambridge University Press, 2009
- : References to journal articles on special themes are given in the lecture

Language:

- offered only in English

Notes:

Admission requirements for the module:
- None

Admission requirements for the examination:
- Examination prerequisites may be defined at the beginning of the semester. If prerequisites are defined, they must have been completed and positively evaluated prior to the initial examination.

The competencies of the following modules are required for this module (no hard admission requirement):
- Algorithms and Data Structures (CS1001).
- Linear Algebra and Discrete Structures I + II (MA1000, MA1500)
- Databases (CS2700)
- Stochastics 1 (MA2510) or Fundamentals of Statistics (PY1800)
- Introduction to Logic (CS1002)
- Artificial Intelligence 1 (CS3204)
- Information Systems (CS4130)

(Equals CS5131)
(Is module part of CS4513, CS4514-KP12)

CS5140 T - Module part: Semantic Web (SemWeba)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Semantic Web (lecture, 2 SWS)
- Semantic Web (exercise, 1 SWS)

Workload:

- 65 Hours private studies
- 45 Hours in-classroom work
- 10 Hours exam preparation

Contents of teaching:

- Introduction with overview of the W3C Semantic Web family of languages
- Data management for Semantic Web data, in particular indexing approaches
- Query processing for Semantic Web queries (central, parallel, and distributed, in particular in the cloud)
- Processing strategies for Semantic Web rules and ontologies

Qualification-goals/Competencies:

- Students can judge about the possibilities and limits of the Semantic Web.
- They can evaluate the consequences of the Semantic Web approach for data modelling, adminstration and processing, and finally for applications.
- They can develop Semantic Web applications.
- They can explain and apply specialized approaches for Semantic Web databases.
- They can discuss about open research questions in the area of the Semantic Web.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- P. Hitzler, M. Krötzsch, S. Rudolph: Foundations of Semantic Web Technologies - Chapman & Hall / CRC, 2009
- T. Segaran, J. Taylor, C. Evans: Programming the Semantic Web - O'Reilly, 2009
- F. Bry, J. Maluszynski: Semantic Techniques for the Web - Springer, 2009
- J. T. Pollock: Semantic Web for Dummies - Wiley, 2009
- J. Hebeler, M. Fisher, R. Blace, A. Perez-Lopez, M. Dean: Semantic Web Programming - Wiley, 2009
- G. Antoniou, F. van Harmelen: A Semantic Web Primer - MIT Press, 2008
- V. Kashyap, C. Bussler, M. Moran: The Semantic Web - Springer, 2008
- S. Groppe: Data Management and Query Processing in Semantic Web Databases - Springer, 2011

Language:

- offered only in German

Notes:

(Is equal to CS5140)
(Is module part of CS4508)

Entry requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- see higher-level module

Module examination(s):
- see superordinate module

CS5150 T - Module part: Organic Computing (OrganicCoa)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester

Classes and lectures:

- Organic Computing (lecture, 2 SWS)
- Organic Computing (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Basic principles of Organic Computing
- Self-organization and emergence
- Architecture and design of Organic Computing systems
- Organic Computing for distributed systems
- Organic Computing in Neuro- and Bionformatics
- Organic Grid
- Autonomous Systems

Qualification-goals/Competencies:

- Students are able to utilize the principles of organic computing on exemplary designs.
- They are able to explain the principles of Organic Computing.
- They are able to analyze emergence behavior in Organic Computing systems.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Computer Engineering
- Dr. rer. nat. Javad Ghofrani

Literature:

- C. Müller-Schloer, H. Schmeck, T. Ungerer: Organic Computing A Paradigm Shift for Complex Systems - Birkhäuser, 2011
- R. P. Würtz: Organic Computing - Springer, 2008
- C. Klüver, J. Kluever, J. Schmidt: Modellierung komplexer Prozesse durch naturanaloge Verfahren - Springer Vieweg 2012

Language:

- offered only in German

Notes:

(Part of Module CS4290, CS4504-KP12)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5150-L1: Organic Computing, oral exam, 100% of the module grade

CS5153 T - Module part: Wireless Sensor Networks (DlSensorNa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Computer Science 2014 (Module part of a compulsory module), specialization field robotics and automation, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), advanced curriculum, Arbitrary semester

Classes and lectures:

- Wireless Sensor Networks (lecture, 2 SWS)
- Wireless Sensor Networks (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Basics of Sensor Networks
- Architecture of Sensor Nodes and Sensor Networks
- Identities and addressing
- Wireless communication
- Data management and topology control
- Localization
- Energy harvesting
- Applications

Qualification-goals/Competencies:

- The students are able to present the potential, benefits and limitations of sensor networks.
- They are able to cope with analysis, design, and evaluation of protocols in sensor networks.
- They are able to interpret and pursue current research activities for sensor networks.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Computer Engineering
- Dr. rer. nat. Javad Ghofrani

Literature:

- H. Karl, A. Willig: Protocols and Architectures of Wireless Sensor Networks, - Wiley, 2005
- F. Zhao, L. Guibas: Wireless Sensor Networks - Morgan Kaufmann, 2004
- B.-C. Renner: Sustained Operation of Sensor Nodes with Energy Harvesters and Supercapacitors - Books on Demand 2013

Language:

- offered only in English

Notes:

(Part of Modules CS4504-KP12)
(Is equal to CS5153)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5153-L1: Wireless Sensor Networks, oral exam, 100% of the module grade

CS5158 T - Module part: Advanced Internet Technologies (AdInternea)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Advanced Internet Technologies (lecture, 2 SWS)
- Advanced Internet Technologies (exercise, 1 SWS)

Workload:

- 60 Hours private studies
- 45 Hours in-classroom work
- 15 Hours exam preparation

Contents of teaching:

- Introduction and fundamentals
- Fundamental Internet design principles
- Problems of today's Internet architecture
- Backbone Technologies
- Mobile Internet
- IPv6 und related topics
- Delay Tolerant Networks (DTN)
- Internet of Services / Internet of Things
- Peer-To-Peer networks
- Big Data
- Goals, architectures, algorithms, and protocols for the future Internet

Qualification-goals/Competencies:

- Understand the fundamental design decisions that have led to today's Internet architecture
- Understand the original design goals of the Internet and realize the implications that the emphasis on certain of them has on today's networks
- Learn about essential, universally valid criteria for the design of networks and applications (e.g., end-to-end argument, fate sharing, etc.)
- Know technological as well as societal developments that have led to massive changes in the Internet's infrastructure (growth, innovations, mobile communications,)
- Identify problems of the Internet's architecture and understand potential solutions by comparing different approaches
- Become acquainted with the Future Internet research field and learn about novel approaches to research and shape the Internet of the future

Grading through:

- exam type depends on main module

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Dr. Mohamed Hail

Literature:

- Olivier Hersent, David Boswarthick, Omar Elloumi: The Internet of Things: Key Applications and Protocols - Wiley, 2012
- Athanasios V. Vasilakos, Yan Zhang, Thrasyvoulos Spyropoulos: Delay Tolerant Networks: Protocols and Applications - CRC Press, 2012
- E. Pacitti, R. Akbarinia, M. El-Dick: P2P Techniques for Decentralized Applications - Morgan & Claypool Publishers

Language:

- German and English skills required

Notes:

(Was module part of CS4509)
(Is equal to CS5158)

Entry requirements to take the module:
- None

Admission requirements for participation in module examination(s):
- See higher-level module

Module examination(s):
- see superordinate module

CS5170 T - Module part: Hardware/Software Co-Design (HWSWCoda)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Hardware/Software Co-Design (lecture, 2 SWS)
- Hardware/Software Co-Design (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- System design flow
- Basic architectures for HW/SW systems
- System design and modelling
- System synthesis
- Algorithms for scheduling
- System partitioning
- Algorithms for system partitioning
- Design systems
- Performance analysis
- System design and specification with SystemC
- Application examples

Qualification-goals/Competencies:

- Students are able to determine a suitable hardware/software architecture for a given system description
- They are able to determine and describe the pros and cons of implementation alternatives
- They are able to apply methods for system partitioning
- They are able to translate non-formal system descriptions into formal models
- They are able to explain the different steps in system synthesis
- They are able to estimate the quality of system designs
- They are able to create system descriptions in SystemC

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- F. Kesel: Modellierung von digitalen Systemen mit SystemC - Oldenbourg Verlag 2012
- Teich, J., Haubelt, C.: Digital Hardware/Software-Systeme. Synthese und Optimierung - Berlin: Springer 2007

Language:

- offered only in German

Notes:

(Is module part of CS4290, CS4505)
(Is equal to CS5170)

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester

Module Exam(s):
- CS5170-L1: Hardware/Software Co-Design, oral exam, 100% of the module grade

CS5194 T - Module part: Practical Project in Signal and Image Processing (PrSigBildv)

Duration:	Turnus of offer:	Credit points:
1 Semester	every second semester	4 (Typ B)

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 1st or 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st or 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- iRoom (practical course, 3 SWS)

Workload:

- 60 Hours group work
- 40 Hours private studies
- 20 Hours written report

Contents of teaching:

- Planning and realization of typical signal processing applications in a team

Qualification-goals/Competencies:

- Students will have comprehensive knowledge of using signal and image processing algorithms in practice.
- They are able to realize signal processing systems in teamwork and in a self-directed manner.
- They have the communication competency to document and present project results.

Grading through:

- exam type depends on main module

Requires:

- Signal processing (CS3100-KP04)
- Image processing (CS3203)

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Markus Kallinger
- MitarbeiterInnen des Instituts

Language:

- offered only in German

Notes:

(Part of Module CS4510)

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- The project must be completed in order to take the exam in the module CS4510

Modul Exam:
- CS4510-L1: Signal Analysis, oral exam consisting out of Pattern Recognition, Selected Topics of Signal Analysis and Enhancement and

this project, 100% of module grade

CS5260SJ14 T - Module part: Speech and Audio Signal Processing (SprachA14a)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the summer semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master Biophysics 2023 (module part), advanced curriculum, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st or 2nd semester
- Master IT-Security 2019 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester

Classes and lectures:

- Speech and Audio Signal Processing (lecture, 2 SWS)
- Speech and Audio Signal Processing (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Speech production and human hearing
- Physical models of the auditory System
- Dynamic compression
- Spectral analysis: Spectrum and Cepstrum
- Spectral perception and masking
- Vocal tract models
- Linear prediction
- Coding in time and frequency domains
- Speech synthesis
- Noise reduction and echo compensation
- Source localization and spatial reproduction
- Basics of automatic speech recognition

Qualification-goals/Competencies:

- Students are able to describe the basics of human speech production and the corresponding mathematical models.
- They are able to describe the process of human auditory perception and the corresponding signal processing tools for mimicing auditory perception.
- They are able to present basic knowledge of statistical speech modeling and automatic speech recognition.
- They can describe and use signal processing methods for source separation and room-acoustic measurements.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Markus Kallinger

Literature:

- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition - Upper Saddle River: Prentice Hall 1993
- J. O. Heller, J. L. Hansen, J. G. Proakis: Discrete-Time Processing of Speech Signals - IEEE Press

Language:

- offered only in German

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of assignments during the semester.

Module examination(s):
- see superordinate module

(Is modul part of CS4290, CS4510, RO4290-KP04)
(Is the same as CS5260SJ14)

CS5275 T - Module part: Selected Topics of Signal Analysis and Enhancement (AMSAVa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (module part), Module part Current Issues Robotics and Automation, 1st and/or 2nd semester
- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Selected Topics of Signal Analysis and Enhancement (lecture, 2 SWS)
- Selected Topics of Signal Analysis and Enhancement (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Introduction to statistical signal analysis
- Autocorrelation and spectral estimation
- Linear estimators
- Linear optimal filters
- Adaptive filters
- Multichannel signal processing, beamforming, and source separation
- Compressed sensing
- Basic concepts of multirate signal processing
- Nonlinear signal processing algorithms
- Application scenarios in auditory technology, enhancement, and restauration of one- and higher-dimensional signals, Sound-field measurement, noise reduction, deconvolution (listening-room compensation), inpainting

Qualification-goals/Competencies:

- Students are able to explain the basic elements of stochastic signal processing and optimum filtering.
- They are able to describe and apply linear estimation theory.
- Students are able to describe the concepts of adaptive signal processing.
- They are able to describe and apply the concepts of multichannel signal processing.
- They are able to describe the concept of compressed sensing.
- They are able to analyze and design multirate systems.
- Students are able to explain various applications of nonlinear and adaptive signal processing.
- They are able to create and implement linear optimum filters and nonlinear signal enhancement techniques on their own.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Markus Kallinger

Literature:

- A. Mertins: Signaltheorie: Grundlagen der Signalbeschreibung, Filterbänke, Wavelets, Zeit-Frequenz-Analyse, Parameter- und

Signalschätzung - Springer-Vieweg, 3. Auflage, 2013
- S. Haykin: Adaptive Filter Theory - Prentice Hall, 1995

Language:
- offered only in German

Notes:

(Part of modules CS4290, CS4510, CS5400, RO4290-KP04, CS5274-KP08)
(Is equal to CS5275)

For Details see main module.

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester (at least 50%).

Modul exam in Main module:
- CS5275-L1: Selected Topics of Signal Analysis and Enhancement, written or oral exam, 100% of modul grade

CS5430 T - module part: Seminar Machine Learning (SemMaschLa)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 2nd semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 2nd semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Seminar Machine Learning (seminar, 2 SWS)

Workload:

- 70 Hours private studies
- 30 Hours in-classroom work
- 20 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- Independent study of a specific field of machine learning

Qualification-goals/Competencies:

- Students can read and understand scientific articles in the field of machine learning.
- Students can present the contents of scientific articles in the field of machine learning in a talk.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr.-Ing. Erhardt Barth
- MitarbeiterInnen des Instituts

Language:

- German and English skills required

Notes:

Admission requirements for the module:
- None

Admission requirements for the examination:
- Examination prerequisites may be defined at the beginning of the semester. If prerequisites are defined, they must have been completed and positively evaluated prior to the initial examination.

(Is part of the module CS4511)

CS5450 T - Module part: Machine Learning (MaschLerna)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	4

Course of study, specific field and term:

- Master Biophysics 2023 (module part), advanced curriculum, 1st semester
- Master Computer Science 2019 (module part), Module part, Arbitrary semester
- Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester
- Master Biophysics 2019 (module part), advanced curriculum, 1st semester
- Master IT-Security 2019 (module part), Module part, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester
- Master MES 2014 (module part), computer science / electrical engineering, 1st or 2nd semester
- Master Computer Science 2014 (module part), Module part, Arbitrary semester

Classes and lectures:

- Machine Learning (lecture, 2 SWS)
- Machine Learning (exercise, 1 SWS)

Workload:

- 55 Hours private studies
- 45 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Representation learning, including manifold learning
- Statistical learning theory
- VC dimension and support vector machines
- Boosting
- Deep learning
- Limits of induction and importance of data ponderation

Qualification-goals/Competencies:

- Students can understand and explain various machine-learning problems.
- They can explain and apply different machine learning methods and algorithms.
- They can chose and then evaluate an appropriate method for a particular learning problem.
- They can understand and explain the limits of automatic data analysis.

Grading through:

- exam type depends on main module

Responsible for this module:

- Siehe Hauptmodul

Teacher:

- Institute for Neuro- and Bioinformatics
- Prof. Dr.-Ing. Erhardt Barth
- Prof. Dr. rer. nat. Thomas Martinetz

Literature:

- Chris Bishop: Pattern Recognition and Machine Learning - Springer ISBN 0-387-31073-8
- Vladimir Vapnik: Statistical Learning Theory - Wiley-Interscience, ISBN 0471030031
- Tom Mitchell: Machine Learning - McGraw Hill. ISBN 0-07-042807-7

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercise assignments as specified at the beginning of the semester.

Module Exam(s):
- CS5450-L1: Machine Learning, oral exam, 100% of module grade.

(Is part of the module CS4290, CS4511, CS5400, CS4251-KP08)

CS4421-KP16 - Case study IT Security (FallstuITS)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	normally each term	16	8

Course of study, specific field and term:

- Master IT-Security 2019 (optional subject), IT-Security, 3rd semester

Classes and lectures:

- Development of a secure IT application (practical course, 14 SWS)

Workload:

- 290 Hours work on project
- 120 Hours private studies and exercises
- 40 Hours written report
- 30 Hours oral presentation (including preparation)

Contents of teaching:

- Project task for a concrete safety-critical problem in the IT area
- Analysis of a safety-critical problem in the IT area, including scientific state of the art
- Selection, clear definition and development of methods to increase safety
- Writing of an exposé outlining the problem, project task, work packages and time managment. Selection of adequate tools (e.g. time-, task- and progress control)
- Prototypical realization of a system with given security requirements while regarding product life cycle and economic efficiency
- Social, ethical and legal aspects of safety-critical systems (e.g. licensing)

Qualification-goals/Competencies:

- The students can recognize, analyze and realize safety requirements.
- The students can analyze complex IT security tasks and work on them in a structured way.
- The students can assess economic, social and legal framework conditions in the development of IT systems.
- The students have basic competencies in project management, can organize themselves as a project team and apply tools adequatly
- In presentation (of their work), students can respond to special audiences or time constraints

Grading through:

- Written report
- Oral presentation
- successful addressing of the project goals

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the internship task
- Documentation and (interim) presentation as specified when the internship is issued

Module examination(s):
- CS4421-L1: Block internship IT security, project execution, documentation and presentation, 100% of module grade.

The internships can be completed at the University of Lübeck as well as at external universities, research institutions and companies with a clear IT security focus in Germany and abroad.

CS4422-KP10 - Case study IT Security (FallstITS)

Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	normally each term	10	8

Course of study, specific field and term:

- Master IT-Security 2019 (optional subject), IT-Security, 3rd semester

Classes and lectures:

- Development of a secure IT application (lecture, 7 SWS)

Workload:

- 170 Hours work on project
- 60 Hours private studies and exercises
- 40 Hours written report
- 30 Hours oral presentation (including preparation)

Contents of teaching:

- Project task for a concrete safety-critical problem in the IT area
- Analysis of a safety-critical problem in the IT area, including scientific state of the art
- Selection, clear definition and development of methods to increase safety
- Writing of an exposé outlining the problem, project task, work packages and time managment. Selection of adequate tools (e.g. time-, task- and progress control)
- Prototypical realization of a system with given security requirements while regarding product life cycle and economic efficiency
- Social, ethical and legal aspects of safety-critical systems (e.g. licensing)

Qualification-goals/Competencies:

- The students can recognize, analyze and realize safety requirements.
- The students can analyze complex IT security tasks and work on them in a structured way.
- The students can assess economic, social and legal framework conditions in the development of IT systems.
- The students have basic competencies in project management, can organize themselves as a project team and apply tools adequatly
- In presentation (of their work), students can respond to special audiences or time constraints

Grading through:

- Written report
- Oral presentation
- successful addressing of the project goals

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the internship task
- Documentation and (interim) presentation as specified when the internship is issued

Module examination(s):
- CS4422-L1: Block internship IT security, project execution, documentation and presentation, 100% of module grade.

The internships can be completed at the University of Lübeck as well as at external universities, research institutions and companies with a clear IT security focus in Germany and abroad.

CS4701-KP06 - Communication and System Security (KoSyS)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (compulsory), IT-Security, 1st or 2nd semester

Classes and lectures:

- Communication and System Security (lecture, 2 SWS)
- Communication and System Security (seminar-style lectures with exercises, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Cryptographic procedures and protocols, security analyses
- IT security at system level, security mechanisms
- Security, privacy and trust of special systems such as Cloud and IoT
- Code analysis
- Security management, legal framework conditions
- Security problems in IT systems

Qualification-goals/Competencies:

- Students can explain the basic methods in the field of cybersecurity and apply them to case studies.
- They can demonstrate a deeper understanding of cryptographic methods and their applications in communication systems.
- They can analyze the entire spectrum of the security of a system.
- They can explain modelling techniques and describe experiences with their use.
- They can apply a variety of standard techniques to increase the security of a system.

Grading through:

- Viva Voce or test
- written homework

Is requisite for:

- Current Topics in IT Security (CS5195-KP04)

Requires:

- Cybersecurity (CS2250-KP04)
- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security

- Prof. Dr.-Ing. Thomas Eisenbarth
- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. Esfandiar Mohammadi

Literature:

- Stallings, Brown: Computer Security: Principles and Practice - 4th ed., Pearson, 2018
- Katz, Lindell: Introduction to Modern Cryptography - 2nd ed., CRC Press, 2014
- Stinson: Cryptography: Theory and Practice - 4th ed., CRC Press, 2018

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS5195-KP04 - Current Topics in IT Security (AktTheITS)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	4

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master IT-Security 2019 (compulsory), IT-Security, 3rd semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester

Classes and lectures:

- Current Topics IT Security and Reliability (seminar-style lectures, 2 SWS)
- Current Topics IT Security and Reliability (project work, 1 SWS)

Workload:

- 45 Hours work on project
- 45 Hours in-classroom work
- 30 Hours private studies and exercises

Contents of teaching:

- new results in cyber security
- design and implementation of a secure system for a complex application and its security analysis

Qualification-goals/Competencies:

- deeper knowledge of current developments in IT security
- professional experience of constructing and analyzing computer systems and networks with respect to security issues

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- Institute for Theoretical Computer Science

- Prof. Dr. Maciej Liskiewicz
- Prof. Dr. Rüdiger Reischuk
- Prof. Dr.-Ing. Thomas Eisenbarth
- Prof. Dr. Esfandiar Mohammadi

Literature:

- papers to be discussed depend on specific topics: -

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- alternates, will be announced at the beginning of the semester

Module Exam(s):
- CS5195-L1: Current Topics in IT Security, oral exam, 100% of module grade.

In the winter semester, the organization and teaching are carried out by ITS, with Professor Thomas Eisenbarth in charge.

In the summer semester, the organization and teaching are carried out by TCS, with Professor Rüdiger Reischuk holding the responsibility.

CS5993-KP30 - Master Thesis IT Security (MScITS)

Duration:	Turnus of offer:	Credit points:
1 Semester	each semester	30

Course of study, specific field and term:

- Master IT-Security 2019 (compulsory), IT-Security, 4th semester

Classes and lectures:

- Master Thesis Media Informatics (supervised self studies, 1 SWS)
- Colloquium (presentation (incl. preparation), 1 SWS)

Workload:

- 870 Hours research for and write up of a thesis
- 30 Hours oral presentation and discussion (including preparation)

Contents of teaching:

- Further qualifications required are subject to private studies.

Qualification-goals/Competencies:

- The students can solve a complex scientific problem with the means of their profession.
- They elaborate a sophisticated scientific work within a given time.
- They have expertise they can apply to problems.
- They are able to analyze, interpret and critically assess scientific literature.
- They possess the communication skills to write down and present their scientific results in an appropriate way.

Grading through:

- oral presentation
- Written report

Responsible for this module:

- Studiengangsleitung IT-Sicherheit

Teacher:

- Institutes of the Department of Computer Science/ Engineering
- Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges

Literature:

- :

Language:

- thesis can be written in German or English

Notes:

Admission requirements for taking the module:
- See study program regulations (e.g. certain minimum CP achieved).

Admission requirements for taking module examination(s):
- CS5993-L2: see examination regulations (e.g. master's thesis assessed with at least sufficient).

Module examination(s):
- CS5993-L1 Master thesis IT Security: master thesis, approx. 67% of the module grade.
- CS5993-L2 Master thesis IT-Security: Colloquium, ca 33% of the module grade

CS4501-KP12, CS4501 - Algorithmics, Logic and Computational Complexity (ALK14)

Duration:	Turnus of offer:	Credit points:
2 Semester	each summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- Algorithmics, Logic and Computational Complexity (lecture, 4 SWS)
- Algorithmics, Logic and Computational Complexity (exercise, 2 SWS)
- Seminar Algorithmics, Logic and Computational Complexity (seminar, 2 SWS)

Workload:

- 160 Hours private studies and exercises
- 120 Hours in-classroom work
- 40 Hours exam preparation
- 40 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- recent results in algorithmics and complexity theory
- communication and circuit complexity
- structural and descriptive complexity theory
- algorithmic game theory
- nonstandard computing models
- understanding logics as a tool

Qualification-goals/Competencies:

- the students can demonstrate a deep knowledge of concepts and methods for algorithm design and complexity analysis.
- They are able to classify algorithmic problems and to select appropriate strategies for their solution
- They are able to model complex problem settings appropriately.
- They can assess and explain the importance of lower bounds for applications.

Grading through:

- Oral examination

Requires:

- Algorithmics (CS4000-KP06, CS4000SJ14)

Responsible for this module:

- Prof. Dr. Kim-Manuel Klein

Teacher:

- Institute for Theoretical Computer Science
- Prof. Dr. Rüdiger Reischuk
- Prof. Dr. rer. nat. Till Tantau
- Prof. Dr. Maciej Liskiewicz
- Prof. Dr. Kim-Manuel Klein

Literature:

- R. Reischuk: Einführung in die Komplexitätstheorie - Teubner, 1990
- S. Arora, B. Barak: Computational Complexity - Cambridge UP 2009
- C. Papadimitriou: Computational Complexity - Addison-Wesley, 1994
- M. Huth, M. Ryan: Logic in Computer Science - Cambridge University. Press 2004
- D. Kozen: Theory of Computation - Springer, 2006

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4503-KP12, CS4503 - Ambient Computing and Applications (AmbCompA)

Duration:	Turnus of offer:	Credit points:
2 Semester	normally each year in the summer semester	12

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (advanced module), advanced curriculum, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- CS4670 T: Ambient Computing (lecture, 3 SWS)
- Seminar Ambient Computing (seminar, 2 SWS)
- Lab Course Ambient Computing (project work, 3 SWS)

Workload:

- 120 Hours group work
- 120 Hours in-classroom work
- 70 Hours private studies
- 30 Hours oral presentation (including preparation)
- 20 Hours exam preparation

Contents of teaching:

- Ambient Computing:
- Current paradigms in computer technology
- Smart components
- Software architectures
- Context-sensitive systems
- Ambient Intelligence
- Interactive ambient media systems
- Ambient Computing Applications (AAL)
- Ethical, Legal and Social Implications (ELSI)

Qualification-goals/Competencies:

- Ambient Computing:
- The students are able to evaluate possibilities, concepts and challenges of Ambient Systems
- They have an overview about current technologies and systems for developing Ambient Systems
- They are able to follow and judge state-of-the-art research in the area of Ambient Computing

Grading through:

- portfolio exam

Responsible for this module:

- Prof. Dr.-Ing. Andreas Schrader

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing. Andreas Schrader

Literature:

- John Krumm: Ubiquitous Computing Fundamentals - CRC Press, 2009
- Stefan Poslad: Ubiquitous Computing: Smart Devices, Environments and Interactions - Wiley, 2009

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project assignment as specified at the beginning of the semester.
- Seminar lecture with elaboration according to the requirements at the beginning of the semester

Module Exam(s):
- CS4503-L1: Ambient Computing and Applications, Portfolio exam consisting of: 20 points in the form of a seminar paper with presentation, 20 points in the form of a project paper and 60 points in the form of an oral exam, 100% of module grade.

(Consists of CS4670 T)

(share of Institute of Telematics in S is 100%)
(share of Institute of Telematics in P is 100%)

CS4504-KP12, CS4504 - Cyber Physical Systems (CPS)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (advanced module), advanced curriculum, 1st or 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- CS5150 T: Organic Computing (lecture with exercises, 3 SWS)
- CS5153 T: Wireless Sensor Networks (lecture with exercises, 3 SWS)
- CS4504-S: Cyber Physical Systems (seminar, 2 SWS)

Workload:

- 220 Hours private studies
- 120 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- basic principles of organic computing / self-x system properties
- from motion to intelligent behavior and system/machine behavior
- design for self-organization, robustness, adaptivity, flexibility, trust
- analyzing, reverse-engineering, debugging machine behavior
- designing experiments and measuring behavior
- modeling system/machine behavior
- complexity, opacity, obscurity, trust of (AI) systems and explainable AI
- architecture of organic computing systems
- applications of self-x systems
- basics of wireless sensor networks
- hardware aspects of sensor nodes
- physics and protocols of wireless communication
- routing in wireless networks
- time synchronization and localization in wireless networks
- data management and data processing in wireless sensor networks
- applications of wireless sensor networks

Qualification-goals/Competencies:

- Students are able to utilize the principles of organic computing/self-x systems on exemplary designs.
- They are able to explain principles of organic computing/self-x systems.
- They are able to analyze system/machine behaviors in a structured, sound approach.
- Students are able to present the pros and cons of sensor networks.
- They are able to cope with analysis, design, and evaluation of protocols in sensor networks.
- They are able to interpret and pursue current research activities for sensor networks.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr. rer. nat. Javad Ghofrani

Literature:

- C. Müller-Schloer, S. Tomforde: Organic Computing Technical Systems for Survival in the Real World - Birkhäuser, 2017
- H. Karl, A. Willig: Protocols and Architectures of Wireless Sensor Networks - Wiley, 2005

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.
- Seminar lecture and elaboration according to the requirements at the beginning of the semester

Module Exam(s):
- CS4504-L1: Cyber Physical Systems, oral exam, 100% of the module grade.

(Consists of CS5150 T, CS5153 T)

CS4505-KP12, CS4505 - System Architecture (SysArch)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- Computer-Aided Design of Digital Circuits (s. CS3110 T) (lecture with exercises, 3 SWS)
- Hardware/Software Co-Design (s. CS5170 T) (lecture with exercises, 3 SWS)
- Lab course System Architecture or Seminar System Architecture (practical course, 3 SWS)

Workload:

- 195 Hours private studies
- 135 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Prof. Dr.-Ing. Mladen Berekovic

Literature:

- :

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.
- Successful completion of the practical tasks according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4505-L1: System Architecture, oral exam, 100% of the module grade.

A seminar can also be offered instead of the internship.

CS4508-KP12, CS4508 - Data Management (DatManag)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd or 3rd semester

Classes and lectures:

- CS4140 T: Mobile and distributed information systems (lecture with exercises, 3 SWS)
- CS5140 T: Semantic Web (lecture with exercises, 3 SWS)
- Seminar data management (seminar, 2 SWS)

Workload:

- 130 Hours private studies
- 120 Hours in-classroom work
- 90 Hours work on an individual topic with written and oral presentation or group work
- 20 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Sven Groppe

Teacher:

- Institute of Information Systems
- Prof. Dr. Sven Groppe

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project assignment as specified at the beginning of the semester or
- Seminar lecture with elaboration according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4508-L1: Data Management, oral exam, 100% of the module grade.

Instead of the seminar, an internship can also be offered.

(Consists of CS4140 T, CS5140 T)

CS4509-KP12, CS4509 - Internet Structures and Protocols / Internet Technologies (Internet)

Duration:	Turnus of offer:	Credit points:
2 Semester	not available anymore	12

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester

Classes and lectures:

- Architectures for Distributed Applications (lecture with exercises, 3 SWS)
- Advanced Internet Technologies (lecture with exercises, 3 SWS)
- Software Architectures (project work, 3 SWS)

Workload:

- 120 Hours in-classroom work
- 105 Hours private studies
- 45 Hours work on project
- 45 Hours group work
- 45 Hours exam preparation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing Horst Hellbrück
- Prof. Dr.-Ing. habil. Dennis Pfisterer

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

(Consists of CS5158 T, CS4151 T).

As of winter semester 2019/20, the module has been renamed from Internet Technologies to Internet Structures and Protocols.

As of winter semester 2020/21, the module is no longer offered to new students.

Admission requirements for taking the module:
- None

Admission requirements for taking module examination(s):
- Successful participation in lab

CS4510-KP12, CS4510 - Signal Analysis (SignalAna)

Duration:	Turnus of offer:	Credit points:
2 Semester	each year, can be started in winter or summer semester	12

Course of study, specific field and term:

- Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester
- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 1st and/or 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and/or 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and/or 3rd semester

Classes and lectures:

- CS5260SJ14 T: Speech and Audio Signal Processing (lecture with exercises, 3 SWS)
- CS5275 T: Selected Topics of Signal Analysis and Enhancement (lecture with exercises, 3 SWS)
- CS5194 T: Lab course (project work, 3 SWS)

Workload:

- 150 Hours private studies
- 90 Hours in-classroom work
- 60 Hours group work
- 40 Hours exam preparation
- 20 Hours written report

Contents of teaching:

- Introduction to statistical signal analysis
- Principles of feature extraction and pattern recognition
- Linear optimum filters
- Adaptive filters
- Spectrum analysis
- Basic concepts of multirate signal processing
- Applications in speech and image processing
- Realization of signal processing tasks for typical application scenarios in teamwork

Qualification-goals/Competencies:

- Students are able to explain the basic elements of stochastic signal processing and optimum filtering.
- They are able to describe and apply linear estimation theory.
- Students are able to describe the concepts of adaptive signal processing.
- They are able to explain theconcepts of feature extraction and pattern recognition.
- They are able to analyze and design multirate systems.
- Students are able to explain various practical applications of signal processing algorithms.
- They are able to create and implement signal processing systems on their own and in teamwork.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Markus Kallinger

Teacher:

- Institute for Signal Processing
- Prof. Dr.-Ing. Markus Kallinger

Literature:

- : See description of module parts

Language:

- German and English skills required

Notes:

Examination prerequisites can be defined at the beginning of the semester. If preliminary work is defined, it must have been completed and positively evaluated before the first examination.

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- CS4510-L3 (all exept Master Biophysics since 2023): Successful completion of the project assignment, seminar presentation and exercise assignments as specified at the beginning of the semester
- CS4510-L1 (only Master Biophysics since 2023): Successful completion of the exercise assignments as specified at the beginning of the semester
- CS4510-L2 (only Master Biophysics since 2023): Successful completion of the project assignment as specified at the beginning of the semester

Module Exam(s):
- CS4510-L3 (all exept Master Biophysics since 2023): Signal Analysis, oral exam, 100% of module grade
- CS4510-L1 (only Master Biophysics since 2023): partial exam Signal Analyse, oral exam, 100% of module grade
- CS4510-L2 (only Master Biophysics since 2023): partial exam Lab course Signal- and image processing, project, ungraded

(Consists of CS4220 T, CS5275 T, CS5194 T)

CS4511-KP12, CS4511 - Learning Systems (LernSys)

Duration:	Turnus of offer:	Credit points:
2 Semester	irregularly	12

Course of study, specific field and term:

- Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester
- Master Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester
- Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester
- Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and AI, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master MES 2014 (advanced module), computer science / electrical engineering, 1st and 2nd semester
- Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and 3rd semester
- Master Computer Science 2014 (advanced module), advanced curriculum, 2nd and 3rd semester

Classes and lectures:

- CS4405 T: Neuro Informatics (lecture with exercises, 3 SWS)
- CS5450 T: Machine Learning (lecture with exercises, 3 SWS)
- CS5430 T: Seminar Machine Learning (seminar, 2 SWS)

Workload:

- 180 Hours private studies
- 120 Hours in-classroom work
- 40 Hours exam preparation
- 20 Hours work on an individual topic with written and oral presentation

Contents of teaching:

- see module parts

Qualification-goals/Competencies:

- see module parts

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. rer. nat. Thomas Martinetz

Teacher:

- Institute for Neuro- and Bioinformatics

- Prof. Dr. rer. nat. Thomas Martinetz
- Prof. Dr.-Ing. Erhardt Barth

Literature:

- : see module parts

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises and project tasks as specified at the beginning of the semester.
- Seminar lecture and elaboration according to the requirements at the beginning of the semester.

Module Exam(s):
- CS4511-L1: Learning Systems, oral exam, 100% of module grade.

(Consists of CS4405 T, CS5450 T, CS5430 T)

Only for computer science students with the application subject Bioinformatics, the course CS4405 T Neuroinformatics is replaced by CS5204 T Artificial Intelligence 2, because this group of participants must already complete Neuroinformatics as part of a required module.

CS4514-KP12 - Intelligent Agents (IntAgents)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	12

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, 1st to 3th semester
- Certificate in Artificial Intelligence (compulsory), Artificial Intelligence, 1st semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and AI, 1st or 2nd semester
- Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester

Classes and lectures:

- CS4514-P: Lab course Intelligent Agents (practical course, 2 SWS)
- CS4514-V: Intelligent Agents (lecture with exercises, 6 SWS)

Workload:

- 195 Hours private studies
- 120 Hours in-classroom work
- 45 Hours exam preparation

Contents of teaching:

- Agents, Mechanisms, and Collaboration: Intelligent agents and artificial intelligence / Game theory and social choice / Mechanism design, algorithmic mechanism design / Agent collaboration, rules of encounter / Continuous Space / Epistemic logic / Knowledge and seeing / Knowledge and time / Dynamic epistemic logic / Knowledge-based programs
- Perception (Language and Vision): Information retrieval and web-mining agents / Probabilistic dimension reduction, latent content descriptions, topic models, LDA, LDA-HMM / Representation learning for sequential structures, embedding spaces, word2vec, CBOW, skip-gram, hierarchical softmax, negative sampling / Language models (1d-CNNs. RNNs, LSTMs, ELMo, Transformers, BERT, GPT-3/OPT, and beyond), Natural language inference and query answering / Computer Vision (2D-CNNs, Deep Architectures: AlexNet, ResNet) /Combining language and vision (CLIP (OpenAI) / LIT (Google) / data2vec (Facebook) / Flamingo (DeepMind), DALL-E and beyond) /Knowledge graph embedding with GNNs, combining embedding-based KG completion with probabilistic graphical models(ExpressGNN, pLogicNet), MLN inference and learning based on embedded knowledge graphs, GMNNs)
- Planning, Causality, and Reinforcement Learning: Planning and acting with deterministic models, temporal models, nondeterministic models, probabilistic models / Standard decision making / Advanced decision making and reinforcement learning / Causal dependencies / Intervention / Instrumental variables / Counterfactuals / Causal planning / Causal reinforcement learning
- In the project lab students use the usual (open source) data science related programming languages and tools in order to transfer the abstractions, concepts and results taught in the lecture into concrete software models and artefacts to be applied on big data.

Qualification-goals/Competencies:

- The students can enumerate central ideas, define the relevant concepts and explain the functioning of algorithms with help of application scenarios for all the items listed in contents of teaching.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr.-Ing. Nele Rußwinkel

Teacher:

- Institute of Information Systems
- Prof. Dr.-Ing. Nele Rußwinkel

Literature:

- J. Pearl, C. Glymour, and N.P. Jewell: Causal Inference in Statistics - A Primer - Wiley, 2016
- Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations - Cambridge University Press, 2009
- S.J. Russell, P. Norvig: Artificial Intelligence: A Modern Approach - Pearson, 2020
- M. Ghallab, D. Nau, P. Traverso: Automated Planning and Acting - Cambridge University Press, 2016

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- successful completion of the Lab Course Intelligent Agents CS4514-P

Module examination(s):
- CS4514-L1: Intelligent Agents, oral examination, 100% of module grade.

(Replaces CS4513-KP12).

CS4517-KP12 - Architectures for Distributed Communication Systems (ArchVeK)

Duration:	Turnus of offer:	Credit points:
2 Semester	each semester	12

Course of study, specific field and term:

- Master IT-Security 2019 (optional subject), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), specific, 2nd or 3rd semester
- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester

Classes and lectures:

- Architectures for distributed communication systems (lecture, 2 SWS)
- Architectures for distributed communication systems (exercise, 1 SWS)
- Mobil communication systems (lecture, 2 SWS)
- Mobil communication systems (exercise, 1 SWS)
- Architectures for distributed communication systems (practical course, 3 SWS)

Workload:

- 120 Hours in-classroom work
- 105 Hours private studies
- 45 Hours work on project
- 45 Hours exam preparation
- 45 Hours group work

Contents of teaching:

- Introduction to Communication Systems and overview of the state-of-the-art technologies
- Wireless Data Link Layer, Network Layer and Technologies (802.15.4, WLAN, GSM, Bluetooth, RFID, LowPowerWANs, Broadcast and Satellite Systems)
- Security in wireless Networks
- Applications of wireless Networks
- Software Architectures
- Basics of communication in distributed networks
- N-Tier Applications
- Architectures of distributed systems (Service-Oriented and Event-Driven Architectures (SOA and EDA), Web-Oriented Architectures (Web 2.0), Overlay Networks, Peer-to-Peer, Grid and Cloud Computing, Internet of Things)

Qualification-goals/Competencies:

- Students can highlight the particularities of wireless mobile communication systems and the challenges and concepts.
- They interpret and follow current research activities and technology trends.
- They can systematically design and evaluate protocols for mobile communication systems and their applications.
- They can design, implement, and operate real-time applications based on wireless communication networks.
- They can analyze technical requirements for mobile radio systems and components and choose solutions.
- They can carry out diagnoses, tests and optimizations of wireless networked mobile communication systems.
- The students are able to name the most important archiectures for distributed systems, explain them, and compare them to each other.
- For each architecture, they know the most prominent and important implementation platforms and basically know how to use them.
- For a given problem, they can analyze which architecture is best suited to solve it, and they can design a plan for the solution's realization.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Prof. Dr.-Ing Horst Hellbrück
- Dr. Mohamed Hail

Literature:

- Jochen Schiller: Mobile Communications - 2nd Edition, Addison-Wesley, 2004, Signature: VK 2650 2005 A 302

- Andrew S. Tanenbaum: Computer Networks - 4th Edition, Prentice-Hall, 2003, Signature: VK 1670 2004 A 823
- Charles E. Perkins: Ad Hoc Networking - 1st Edition, Addison Wesley Professional, December 2000, Signature: VK 1670 2002 A 640
- J. Dunkel, A. Eberhart, S. Fischer, C. Kleiner, A. Koschel: Systemarchitekturen für verteilte Anwendungen - Hanser-Verlag 2008
- I. Melzer et.al.: Service-Orientierte Architekturen mit Web Services - Spektrum-Verlag 2010

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of the project internship

Module Examination(s):
- CS4517-L1: Architectures for Distributed Communication Systems, oral exam, 100% of module grade.

According to the decision of the Examination Board for Computer Science of 17.7.2020, this module can be chosen as a specialization module for Master Computer Science.

CS4518-KP12 - Current and Future Network Technologies (AzuNet)

Duration:	Turnus of offer:	Credit points:
2 Semester	each semester	12

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester
- Master IT-Security 2019 (optional subject), Elective Computer Science, 1st or 2nd semester
- Master Entrepreneurship in Digital Technologies 2020 (optional subject), specific, Arbitrary semester

Classes and lectures:

- Advanced Internet Technologies (lecture, 2 SWS)
- Advanced Internet Technologies (exercise, 1 SWS)
- Nano communication networks (lecture, 2 SWS)
- Nano communication networks (project work, 1 SWS)
- Seminar Internet of Things or Seminar Nano communication networks (seminar, 2 SWS)

Workload:

- 165 Hours private studies
- 105 Hours in-classroom work
- 45 Hours exam preparation
- 30 Hours work on an individual topic with written and oral presentation
- 15 Hours work on project

Contents of teaching:

- Fundamental Internet design principles
- Problems of today's Internet architecture
- Backbone Technologies
- Mobile Internet
- IPv6 und related topics
- Delay Tolerant Networks (DTN)
- Internet of Services / Internet of Things
- Peer-To-Peer networks
- Big Data
- Goals, architectures, algorithms, and protocols for the future Internet
- Self-assembly systems
- Reductions and compilation
- Definitions & associations of nanonetworks
- Simulation tools for nanonetworks
- Deployment in medical application scenarios

Qualification-goals/Competencies:

- Understand the fundamental design decisions that have led to today's Internet architecture
- Understand the original design goals of the Internet and realize the implications that the emphasis on certain of them has on today's networks
- Learn about essential, universally valid criteria for the design of networks and applications (e.g., end-to-end argument, fate sharing, etc.)
- Know technological as well as societal developments that have led to massive changes in the Internet's infrastructure (growth, innovations, mobile communications,)
- Identify problems of the Internet's architecture and understand potential solutions by comparing different approaches
- Become acquainted with the Future Internet research field and learn about novel approaches to research and shape the Internet of the future
- They can design, implement and test basic IoT applications.
- They can efficiently collect, analyze and interpret data from IoT systems.
- They can deal with real-world use cases and be able to develop solutions for specific industries.
- They recognize the current trends and future developments in the IoT area and can evaluate them critically.
- Students know and understand the basic concepts of nanonetworks.
- Students know the basic concepts of nanoscale computational models.
- Students know and understand self-assembly systems and crystal formation.
- Students know and understand the constraints and peculiarities at the nanoscale.
- Students know how to verify or falsify a model using simulation tools.
- Students can transfer basic theoretical concepts to related questions.

Grading through:

- Oral examination

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Dr. Mohamed Hail
- Dr. rer. nat. Florian-Lennert Lau

Literature:

- Olivier Hersent, David Boswarthick, Omar Elloumi: The Internet of Things: Key Applications and Protocols - Wiley, 2012

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful participation in the seminar

Module Exam(s):
- CS4518-L1: Current and Future Network Technologies, oral exam, 100% of module grade.

CS4210-KP06, CS4210 - Cryptographic Protocols (KrypProto)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the summer semester	6

Course of study, specific field and term:

- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester

Classes and lectures:

- Cryptographic Protocols (lecture, 3 SWS)
- Cryptographic Protocols (exercise, 1,5 SWS)

Workload:

- 85 Hours private studies and exercises
- 75 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Complex cryptographic protocols, security analyses
- Anonymity and Privacy, Private Computation and Information Retrieval, Differential Privacy
- Quantum Cryptographie
- Steganography, digital seals and watermarks
- secure e-commerce, electronic money, online elections

Qualification-goals/Competencies:

- The students can reason about cryptographic methods and their application in communication systems.
- The are able to select suitable security primitives for given applications and to implement them.
- The can conduct a security analysis of communication protocols.
- They can designate the weaknesses of real systems and evaluate them.

Grading through:

- Oral examination

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science
- Prof. Dr. Maciej Liskiewicz
- Prof. Dr. Rüdiger Reischuk

Literature:

- Lindell: Tutorials on the Foundations of Cryptography - Springer 2017
- J. Katz, Y. Lindell: Introduction to Modern Cryptography - CRC Press 2014
- Goldreich: Fundamentals of Cryptography - Cambridge Univ. Press 2004
- I. Cox, M. Miller, J. Bloom, J. Fridrich, T. Kalkerm: Digital Watermarking and Steganography - Morgan Kaufmann 2008
- Dwork, Roth: The Algorithmic Foundations of Differential Privacy - 2014

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4211-KP06, CS4211 - Modeling and Analysing Security (SecurAna_a)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester
- Master Medical Informatics 2014 (optional subject), major subject informatics, 1st or 2nd semester

Classes and lectures:

- Modeling and Analysing Security (lecture, 3 SWS)
- Modeling and Analysing Security (exercise, 1 SWS)
- Modeling and Analysing Security (practical course, 1 SWS)

Workload:

- 85 Hours private studies and exercises
- 75 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Modelling and formalizing protocols and security properties
- Adversaries and models of attacks, security pitfalls
- Symbolic methods and automatic verification of security properties
- Consistency and synchronization

Qualification-goals/Competencies:

- The students can comprehensively elaborate on algorithmic basics for IT security.
- They can report on security properties.
- They can recite complex methods for IT security and apply them.
- They are able to specify, analyse and verify protocols and security properties.
- They can describe techniques for automatic verification of security properties.

Grading through:

- Oral examination

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr. Rüdiger Reischuk

Teacher:

- Institute for Theoretical Computer Science
- Prof. Dr. Maciej Liskiewicz
- Prof. Dr. Rüdiger Reischuk

Literature:

- V. Cortier, S. Kremer, editors: Formal Models and Techniques for Analyzing Security Protocols - Cryptology and Information Security Series 5, IOS Press, 2011
- C. P. Pfleeger, S. L. Pfleeger: Security in Computing - Prentice-Hall, 2007
- A. Joux: Algorithmic Cryptanalysis - CRC Press 2009
- J. Katz, Y. Lindell: Introduction to Modern Cryptography - Chapman & Hall 2008
- S. Loepp, W. Wootters: Protecting Information - Cambridge Univ. Press 2006

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4450-KP06 - Networks and Mobile Systems (NetzeMobSy)

Duration:	Turnus of offer:	Credit points:
1 Semester	Currently not available	6

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- Networks and Mobile Systems (lecture, 2 SWS)
- Networks and Mobile Systems (exercise, 2 SWS)

Workload:

- 90 Hours private studies
- 60 Hours in-classroom work
- 30 Hours exam preparation

Contents of teaching:

- Introduction into the special security problems of mobile systems
- Security Architectures for wireless wide area netwirks (GSM, UMTS, LTE)
- Security in Wireless Local Area Networks (WLAN, Bluetooth)
- Security in the Internet of Things (basics, key management, integrity, authenticity, RFID)
- Security for embedded devices

Qualification-goals/Competencies:

- The successful participants understand the central concepts, methods, and mechanisms to secure wireless networks and mobile systems.
- They are able to correctly apply existing solutions, develop own new solutions and assess their validity.
- They are able to assess new security problems and solutions coming from research.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Stefan Fischer

Teacher:

- Institute of Telematics
- Prof. Dr. Stefan Fischer

Literature:

- Claudia Eckert: IT-Sicherheit - Oldenbourg, 8th ed., 2013

Language:

- German and English skills required

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- none

Module Exam(s):
- CS4450-L1: Networks and Mobile Systems, oral examination, 100% of module grade.

CS4451-KP06 - Privacy (Privacy)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- Privacy (lecture, 2 SWS)
- Privacy (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Private statistics (Differential Privacy)
- Privacy preserving machine learning
- Privacy attacks against machine-learned models
- Privacy-preserving computation in distributed systems.
- Stylometry: de-anonymization via writing style
- Anonymity

Qualification-goals/Competencies:

- Deep understanding for algorithmic and algebraic methods to secure private data
- Skills to analyze complex security requirements

Grading through:

- Oral examination

Requires:

- Trustworthy AI (CS5075-KP06)

Responsible for this module:

- Prof. Dr. Esfandiar Mohammadi

Teacher:

- Institute for IT Security
- Prof. Dr. Esfandiar Mohammadi

Literature:

- C. Dwork, A. Roth: The Algorithmic Foundations of Differential Privacy - Now Publishers Inc, 2014
- Stanford: Encyclopedia of Philosophy on Privacy
- Andrej Bogdanov: Lecture notes by Andrej Bogdanov from Chinese University of Hong Kong
- Journal und Konferenz-Publikationen: wird aktuell benannt

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4702-KP06 - Computer Security (CoSec)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the summer semester	6

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- Computer Security (lecture, 2 SWS)
- Computer Security (practical course, 3 SWS)

Workload:

- 85 Hours private studies
- 75 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Applied cryptography in systems and protocols: Overview of common methods and their applications
- Efficient and secure implementation of common crypto procedures: multiple-precision arithmetic, efficient exponentiation, constant time algorithms etc.
- Physical implementation attacks and countermeasures: Error injection attacks, passive physical attacks such as SPA/DPA and timing attacks, modern inference methods and associated cryptanalysis methods, classes of protective measures
- Virtualization security and microarchitecture attacks: security concepts in the operating system and hypervisor, microarchitecture attacks such as cache attacks, spectre, etc., measures to restore system security
- Trusted computing and hardware-assisted system security: How TPMs, Secure Elements and Trusted Execution work environments, basics and cryptographic techniques, design basics for secure systems

Qualification-goals/Competencies:

- The students can demonstrate a deep understanding of cryptographic methods and their applications in communication systems.
- They can construct secure and efficient cryptographic primitives and implement them securely in computer systems.
- They can explain methods and algorithms for efficient multiple-precision arithmetic.
- They can perform basic side-channel attacks on systems with physical access or shared systems with code execution rights.
- They can implement protection against specific physical attacks for cryptographic primitives.
- They can evaluate the security of existing primitives.

Grading through:

- Viva Voce or test
- written homework

Requires:

- Cybersecurity (CS2250-KP04)

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- Prof. Dr.-Ing. Thomas Eisenbarth

Literature:

- S. Mangard, E. Oswald & T. Popp: Power analysis attacks: Revealing the secrets of smart cards - Vol. 31, Springer Science & Business Media, 2008
- D. Stinson: Cryptography: Theory and Practice - 4th ed., CRC Press, 2018
- : Recent literature

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4703-KP06 - Advanced Cryptology (AdvCrypto)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master CLS 2016 (optional subject), computer science, 3rd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, Arbitrary semester

Classes and lectures:

- Lecture Advanced Cryptoplogy (lecture, 3 SWS)
- Exercise Advanced Cryptoplogy (seminar-style lectures with exercises, 1 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Concrete security and asymptotic security: comparison of both approaches in relation to modes of operations
- Block-Ciphers: Feistel Networks, Substitution-Permutation Networks, Design Principles, Linear Cryptanalysis, Differential cryptanalysis
- Authenticated Encryption
- Secure multi-party calculations: preprocessing model, protection of algorithms against side-channel attacks, MPC-in-the-Head (for ZK evidence)
- Obfuscation: Nicht-Machbarkeit (BlackBox), Machbarkeit (indistinguishable Obfuscation)

Qualification-goals/Competencies:

- The participants can explain and use basic theoretic cryptographic objects
- They are able to understand current concepts of cryptography
- They show a deep understanding of cryptographic methods
- They understand the basic connection between theoretical and practical aspects of cryptography
- They are able to understand current scientific works about cryptography and explain them

Grading through:

- Written or oral exam as announced by the examiner
- written homework

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr.-Ing. Thomas Eisenbarth

Teacher:

- Institute for IT Security
- Dr Sebastian Berndt

Literature:

- Katz, Lindell: Introduction to Modern Cryptography - 2nd ed., CRC Press, 2014
- Cramer, Damgård, Nielsen: Secure Multiparty Computation and Secret Sharing - 1st ed., Cambridge University Press, 2015
- Barak: An Intensive Introduction to Cryptography - Lecture Notes

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None (the competencies under

CS4705-KP06 - Cryptographic Engineering (CryEng)

Duration:	Turnus of offer:	Credit points:
1 Semester	every summer semester	6

Course of study, specific field and term:

- Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester
- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- Cryptographic Engineering (lecture, 2 SWS)
- Cryptographic Engineering (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Efficient Implementation of Finite Field Arithmetic for cryptographic Applications.
- Stream Ciphers: Design and hardware Implementation.
- Block Ciphers: Design, hardware Implementation, and Lightweight Encryption Algorithms.
- Hash Functions: Design and hardware Implementation.
- Public-Key Cryptography over GF(2m): Design and Implementation.
- True and Pseudo Random Number Generators (TRNG): Design, test, and hardware Implementation.
- Physical Unclonable Functions (PUFs): Design Challenges and Hardware- Architectures.

Qualification-goals/Competencies:

- Students will become familiar with the concept of cryptographic engineering and the associated topics with it.
- They can expand and enhance their knowledge about a cryptography and applied cryptography.
- They can become more familiar with the concepts of hardware-security.
- They can learn efficient implementation of Finite Field Arithmetic in hardware and its applications in cryptography.
- They can learn the techniques for hardware-implementation of cryptographic algorithms
- They can demonstrate a deep understanding of several structures and designs of stream and block ciphers
- They can take an advanced step towards hardware and physical security such as TRNG, PUFs.

Grading through:

- written exam

Requires:

- Cryptology (CS3420-KP04, CS3420)

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr.-Ing. Saleh Mulhem

Literature:

- Ferguson, Niels, Bruce Schneier, and Tadayoshi Kohno: Cryptography Engineering: Design Principles and Practical Applications - 2012
- Koç Ç.K.: Cryptographic Engineering - Springer, Boston, MA, (2009)
- Wachsmann, Christian, and Ahmad-Reza Sadeghi: Physically unclonable functions (PUFs): Applications, models, and future directions - Morgan & Claypool Publishers, 2014
- Johnston, David: Random Number Generators Principles and Practices: A Guide for Engineers and Programmers - Walter de Gruyter GmbH & Co KG, 2018

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module examination(s):
- CS4705-L1: Cryptographic Technology, written exam, 90min, 100% of module grade.

CS5075-KP06 - Trustworthy AI (TrustAI)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master Medical Informatics 2019 (optional subject), ehealth / infomatics, 1st or 2nd semester
- Master IT-Security 2019 (optional subject), IT Security and Privacy, 1st, 2nd, or 3rd semester

Classes and lectures:

- CS5075-V: Trustworthy AI (lecture, 3 SWS)
- CS5075-Ü: Trustworthy AI (exercise, 1 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Guiding principles of Trustworthy AI: lawful, ethical and robust AI
- Trustworthy Computing Basics: Security, Privacy, Dependability, Safety, Transparency, Explainability, Traceability, Accountability
- De-anonymization methods using machine learning models
- Mathematical notions for privacy-preserving machine learning methods
- Privacy-preserving machine learning methods
- Analyse maschinell gelernter Modellen (Robustness Check, Explainability)
- Verifikation maschinell gelernter Modellen ((Statistical Testing), Model Checking)
- Black-Box methods for extracting machine learning models (for economical reasons, for analysis, and for verification)
- Attacks for manipulating machine learning models (adversarial examples, backdoors)
- Hardening of machine learning methods against manipulation methods
- Robust machine learning methods against manipulation attacksSecure and privacy-preserving distributed learning methods (Privacy-Preserving Federated Learning)

Qualification-goals/Competencies:

- All current techniques taught in the module and described above can be named and defined by the students and their functional proofs can be explained on the basis of applications.
- The formal foundations from the course can be precisely explained
- Students are able to identify advantages and disadvantages of planning and acting approaches
- Understanding about potential vulnerabilities of machine learning methods w.r.t. privacy-violations and manipulation possibilities
- Understanding of hardening methods compared to deanonymization and manipulation methods
- Students can analyze complex security requirements

Grading through:

- Oral examination

Is requisite for:

- Privacy (CS4451-KP06)

Responsible for this module:

- Prof. Dr. Esfandiar Mohammadi

Teacher:

- Institute of Software Technology and Programming Languages
- Institute for IT Security

- Prof. Dr.-Ing. Thomas Eisenbarth
- Prof. Dr. Martin Leucker
- Prof. Dr. Esfandiar Mohammadi

Literature:

- C. Dwork, A. Roth: The Algorithmic Foundations of Differential Privacy - Now Publishers Inc, 2014
- Andrej Bogdanov: Lecture notes by Andrej Bogdanov from Chinese University of Hong Kong
- : Current conference and journal articles on the topics of the event will be announced at the beginning of the event in the case of the

seminar and at the discussion of the topic in the case of the lecture.

Language:

- offered only in English

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises and project tasks as specified at the beginning of the semester.

Module Exam(s):
- CS5075-L1: Trustworthy AI, oral examination, 100% of module grade.

According to the decision of the examination board of computer science from 19.1.2022 this module can be chosen for Master SGO from WS 2019 in the area 5. elective.

CS4138-KP06, CS4138SJ14 - Model Checking (ModelChe14)

Duration:	Turnus of offer:	Credit points:
1 Semester	each winter semester	6

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 1st or 2nd semester

Classes and lectures:

- Model Checking (lecture, 3 SWS)
- Model Checking (exercise, 1 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Quality aspects of software systems
- Analysis and verification techniques for software systems
- Basic techniques for model checking
- Advanced techniques for model checking

Qualification-goals/Competencies:

- The students can describe and compare analysis and verification techniques.
- They can construct, analyse and evaluate specifications of correctness and safety properties.
- They can characterize different system models and can formally represent sysstems in suitable models.
- They can illustrate different techniques for model checking hardware and software systems and can select and apply suitable techniques.
- They can explain the structure of model checkers and can use model checkers.
- They can evaluate the possibilities and limitations of model checking.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- C. Baier, J.-P. Katoen: Principles of Model Checking - MIT Press, 2008

Language:

- English, except in case of only German-speaking participants

Notes:

Prerequisites for attending the module:
- None

Prerequisites for the exam:
- Successful completion of homework assignments during the semester

CS4139-KP06, CS4139 - Runtime Verification and Testing (RVTesten)

Duration:	Turnus of offer:	Credit points:
1 Semester	each summer semester	6

Course of study, specific field and term:

- Master MES 2020 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Media Informatics 2020 (optional subject), computer science, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester
- Master MES 2014 (optional subject), computer science / electrical engineering, Arbitrary semester
- Master Medical Informatics 2014 (optional subject), computer science, 1st or 2nd semester
- Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester
- Master Computer Science 2014 (optional subject), specialization field IT security and safety, 1st or 2nd semester

Classes and lectures:

- Runtime Verification and Testing (lecture, 3 SWS)
- Runtime Verification and Testing (exercise, 1 SWS)

Workload:

- 100 Hours private studies and exercises
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Quality aspects of software systems
- Analysis and verification techniques for software systems
- Testing levels
- Testing process
- Kinds of tests
- Test case generation
- Specification of correctness properties
- synthesis of monitors for the observation of software systems
- diagnosis of errors in software systems
- realization of monitoring frameworks

Qualification-goals/Competencies:

- The students can describe and compare analysis and verification techniques.
- They can construct, analyse and evaluate specifications of correctness and safety properties.
- They can illustrate different techniques for testing hardware and software systems and can select and apply suitable techniques.
- They can explain the operation process of test case generation tools and can clasify suitable applications.
- They can describe and apply techniques for the synthesis of monitors.
- With the acquired techniques they can develop software of higher quality.

Grading through:

- Written or oral exam as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- G.J. Myers: The Art of Software Testing - John Wiley, 1979
- B. Beizer: Software Testing Techniques - Van Nostrand Reinhold, 1999
- M. Broy, B. Jonsson, J.-P. Katoen, M. Leucker, A. Pretschner: Model-Based Testing of Reactive Systems - Springer, 2005
- A. Bauer, M. Leucker, C. Schallhart: Runtime Verification for LTL and TLTL - ACM TOSEM, 2011
- C. Baier, J.-P. Katoen: Principles of Model Checking - MIT Press, 2008
- D. Peled: Software Reliability Methods - Springer, 2001

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- CS4139-L1: Runtime Verification and Testing, oral exam, 100% of the module grade.

CS4452-KP06 - Reliability Engineering (TechZuv)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	6

Course of study, specific field and term:

- Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, Arbitrary semester
- Master Computer Science 2019 (optional subject), Elective, Arbitrary semester
- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester

Classes and lectures:

- Reliability Engineering (lecture, 2 SWS)
- Reliability Engineering (exercise, 2 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Basic concepts
- Reliability analysis
- Qualification tests
- Maintainability analysis
- Design guidelines for reliability, maintainability and software quality

Qualification-goals/Competencies:

- Students are able to discuss the basic concepts of Reliabilty Engineering
- They are able to analyze the reliability of technical systems by mathematical models
- They are able to select and apply qualification tests
- They are able to perform a maintainability analysis
- They are able to follow design guidelines for reliable and maintainable systems.

Grading through:

- Viva Voce or test

Responsible for this module:

- Prof. Dr.-Ing. Mladen Berekovic

Teacher:

- Institute of Computer Engineering
- Dr.-Ing. Saleh Mulhem

Literature:

- A. Birolini: Reliability Engineering: Theory and Practice - Springer 2013
- M. Rausand: Reliability of Safety-Critical Systems - Wiley 2014

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- CS4452-L1: Technical Reliability, written exam, 90min, 100% of the module grade.

According to the decision of the examination board of computer science of 15.1.2020 this module can be chosen by students Master Computer Science SGO from 2019 in the area of 5th elective.

CS5220-KP06 - Static Analysis (StatAna)

Duration:	Turnus of offer:	Credit points:
1 Semester	normally each year in the winter semester	6

Course of study, specific field and term:

- Master IT-Security 2019 (optional subject), IT Safety and Reliability, 1st, 2nd, or 3rd semester

Classes and lectures:

- Static Analysis (lecture, 3 SWS)
- Static Analysis (exercise, 1 SWS)

Workload:

- 100 Hours private studies
- 60 Hours in-classroom work
- 20 Hours exam preparation

Contents of teaching:

- Definitions, capabilities, differentiation
- Program analysis
- Data flow analysis
- Abstract Interpretation
- Symbolic Execution
- SMT/SAT Solvers
- Hoare logic, wp calculus
- Software metrics
- Bytecode analysis
- Manual code inspection

Qualification-goals/Competencies:

- The students can illustrate the capabilities of static analysis.
- They can explain and classify the techniques for automatic static source code analysis.
- They can select appropriate analysis methods, and employ and combine them.
- They can relate, compare and evaluate various static methods in order to increase software quality.
- They can describe approaches for bytecode analysis.
- They can select and apply common tools for static analysis.
- They can organize and execute manual code inspections.

Grading through:

- written exam, oral exam and/or presentation as announced by the examiner

Responsible for this module:

- Prof. Dr. Martin Leucker

Teacher:

- Institute of Software Technology and Programming Languages
- Prof. Dr. Martin Leucker

Literature:

- F. Nielson, H.R. Nielson, C. Hankin: Principles of Program Analysis - Springer, 2010
- H. Seidl, R. Wilhelm, S. Hack: Übersetzerbau Band 3: Analyse und Transformation - Springer 2010

Language:

- English, except in case of only German-speaking participants

Notes:

Admission requirements for taking the module:
- None

Admission requirements for participation in module examination(s):
- Successful completion of exercises as specified at the beginning of the semester.

Module Exam(s):
- CS5220-L1: Static Analysis, oral exam, 100% of module grade.