

UNIVERSITÄT ZU LÜBECK

# Module Guide for the Study Path

# **Master IT-Security 2019**

Version from 1. April 2025



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CS4130-KP06, CS4130 - Information Systems (InfoSys)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		6	
Course of study, specific field and a Master Computer Science 201 Master Entrepreneurship in D Master Media Informatics 202 Master Computer Science 201 Master Medical Informatics 202 Master Robotics and Autonor Master Robotics and Autonor Master IT-Security 2019 (basic Master Medical Informatics 201 Master Media Informatics 201 Master Entrepreneurship in D Master Computer Science 201 Master Computer Science 201	serm: 9 (compulsory), Canonical Speciali igital Technologies 2020 (basic mo 0 (optional subject), computer scie 9 (basic module), Applied comput nous Systems 2019 (optional subje module), Applied computer scien 014 (basic module), ehealth / infor 4 (optional subject), computer scie igital Technologies 2014 (basic mo 4 (optional subject), specialization 4 (basic module), Applied comput	ization Data Science and idule), Applied computer ence, Arbitrary semester er science, 1st or 2nd ser uter science, 1st or 2nd se ect), Elective, 1st or 2nd se ce, 1st or 2nd semester natics, 1st or 2nd semester dule), Applied computer field software systems e er science, 1st or 2nd ser	l Al, Arbitrary semester r science, 1st or 2nd semester mester emester semester er r science, 1st or 2nd semester engineering, 2nd or 3rd semester mester	
Classes and lectures:		Workload:		
<ul> <li>Information Systems (lecture,</li> <li>Information Systems (exercise</li> </ul>	2 SWS) 2, 2 SWS)	<ul><li>100 Hours priva</li><li>60 Hours in-clas</li><li>20 Hours exam</li></ul>	ate studies ssroom work preparation	
<ul> <li>Motivation of knowledge gra</li> <li>Overview over the W3C Sema</li> <li>Comparison between and the</li> <li>Graph Neural Networks and t</li> </ul>	phs and their relationship to the Se Intic Web family of languages Interaction of knowledge graphs heir applications for tasks of know	emantic Web and generative artificial ledge graphs	intelligence such as large language models	
<ul> <li>Qualification-goals/Competencies:</li> <li>Knowledge: Students acquire as large language models and</li> <li>Skills: Students can assess the consequences of the Semant develop Semantic Web applie networks to solve tasks for ar graphs and the semantic web</li> <li>Social skills and independence work is encouraged through</li> </ul>	an overview of knowledge graphs d graph neural networks. e possibilities and limitations of kno c Web approach for data modeling cations. They can use generative ar id in addition to knowledge graphs as well as in comparison to gener e: Students work in groups to com exercises, some of them directly or	and the Semantic Web owledge graphs and the g, data administration an tificial intelligence such s. They can discuss open ative artificial intelligenc plete exercises and smal n the computer.	as well as generative artificial intelligence such Semantic Web. They can estimate the nd processing and for applications. They can as large language models and graph neural research questions in the area of knowledge ce and graph neural networks. Il projects. Students' independent practical	
Grading through:				
Written or oral exam as anno	unced by the examiner			
Responsible for this module: • Prof. Dr. Sven Groppe Teacher: • Institute of Information Syster • Prof. Dr. Sven Groppe	ms			
Literature: • M. Kejriwal, C. Knoblock: Knov • S. Groppe: Data Management • W. L. Hamilton: Graph Repres International Publishing, 2020 • D. Jurafsky, J. H. Martin: Speed • D. Foster: Generative deep lea	wledge graphs - MIT Press, 2021 and Query Processing in Semantic entation Learning. In Synthesis Lec ) ch and language processing - Uppo arning - Sebastopol, CA: O Reilly N	c Web Databases - Spring ctures on Artificial Intellig er Saddle River, NJ: Pears Iedia, 2023	ger, 2011 gence and Machine Learning - Springer son, 2008	



### 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





CS	4150-KP06, CS4150SJ14 - Di	stributed Systems (VertSys14)
Duration:	Turnus of offer:	Credit points:
l Semester	each winter semester	6
Course of study, specific field and Master Computer Science 20 Master Entrepreneurship in 1 Master Media Informatics 20 Master Computer Science 20 Master Medical Informatics 2 Master Robotics and Autono Master IT-Security 2019 (bas Master Medical Informatics 2 Master Medical Informatics 2 Master Medical Informatics 2 Master Entrepreneurship in 1 Master Computer Science 20 Master Computer Science 20	term: 19 (compulsory), Canonical Speciali Digital Technologies 2020 (basic mo 20 (optional subject), computer scie 19 (basic module), Applied comput 019 (basic module), Applied comput mous Systems 2019 (optional subje c module), Applied computer scien 014 (basic module), ehealth / infor 14 (optional subject), computer scie Digital Technologies 2014 (basic mo 14 (optional subject), specialization 14 (basic module), Applied comput	zation SSE, Arbitrary semester dule), Applied computer science, 1st or 2nd semester ence, Arbitrary semester er science, 1st or 2nd semester tter science, 1st or 2nd semester ct), Elective, 1st or 2nd semester ce, 1st or 2nd semester ence, Arbitrary semester ence, Arbitrary semester dule), Applied computer science, 1st or 2nd semester field software systems engineering, 2nd or 3rd semester er science, 1st or 2nd semester
Classes and lectures:		Workload:
<ul> <li>Distributed Systems (lecture, 2 SWS)</li> <li>Distributed Systems (exercise, 2 SWS)</li> <li>Obstributed Systems (exercise, 2 SWS)</li> </ul>		<ul> <li>60 Hours in-classroom work</li> <li>60 Hours private studies</li> <li>40 Hours e-learning</li> <li>20 Hours exam preparation</li> </ul>
<ul> <li>Realization of network service</li> <li>Communication mechanism</li> <li>Addresses, names and direct</li> <li>Synchronisation</li> <li>Replication and consistency</li> <li>Fault tolerance</li> <li>Distributed transactions</li> <li>Security</li> </ul>	tes s ory services	
<ul> <li>Qualification-goals/Competencies</li> <li>The participants will accquir handling, naming etc.</li> <li>They know the most import.</li> <li>They are able to program sir</li> <li>They know the most import. mutual exclsuion.</li> <li>They have a good feeling fo</li> <li>They have a good feeling fo</li> </ul>	: e a deep understanding for problen ant services in distributed systems s nple distributed applications and sy ant algorithms in distributed system r when it makes sense to use distrib r what kind of solutions could best b	ns to be solved in distributed systems, such as synchronization, error uch as name service, distributed file systems etc. istems themselves. is, for instance for time synchronization, for leader election, or for uted instead of centralized systems. 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 L	au	



<ul> <li>Literature:</li> <li>A. Tanenbaum, M. van Steen: Distributed Systems: Principles and Paradigms - Prentice Hall 2006</li> <li>G. Coulouris, J. Dollimore, T. Kindberg, G. Blair: Distributed Systems - Concepts and Design - Addison Wesley 2012</li> </ul>
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
<ul> <li>Course of study, specific field and term:         <ul> <li>Master Computer Science 2019 (compulsory), Canonical Specialization Data Science and AI, Arbitrary semester</li> <li>Master Computer Science 2019 (compulsory), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (basic module), Theoretical computer science, 1st or 2nd semester</li> <li>Master Medical Informatics 2019 (optional subject), Theoretical computer science, 1st or 2nd semester</li> <li>Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester</li> <li>Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester</li> <li>Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester</li> <li>Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester</li> <li>Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester</li> <li>Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester</li> <li>Master IT-Security 2019 (compulsory), Theoretical computer science, 1st or 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (basic module), technology field computer science, 1st or 2nd semester</li> <li>Master Computer Science 2014 (optional subject), specialization field IT security and safety, 2nd or 3rd semester</li> <li>Master Computer Science 2014 (basic module). Theoretical computer science, 1st or 2nd semester</li> </ul> </li> </ul>			
Classes and lectures:		Workload:	
<ul> <li>Algorithmics (lecture, 2 SWS)</li> <li>Algorithmics (exercise, 2 SWS)</li> </ul>	re, 2 SWS)• 100 Hours private studies and exercisescise, 2 SWS)• 60 Hours in-classroom work• 20 Hours exam preparation		
<ul> <li>Contents of teaching:</li> <li>complexity analysis of algorithmic problems</li> <li>discrete optimization problems, linear programming</li> <li>satisfiability and constraint satisfaction problems</li> <li>randomized algorithms</li> <li>approximation algorithms and heuristics</li> <li>algorithms for algebraic problems</li> </ul>			
<ul> <li>Qualification-goals/Competencies:</li> <li>The students can model real problems in an algorithmic manner.</li> <li>They can apply basic algorithmic techniques with full command.</li> <li>They can analyze algorithms, in particular with respect to corrrectness and complexity.</li> <li>They can design efficient algorithms for complex problems.</li> </ul>			
Grading through: • written exam			
Requires: • Theoretical Computer Science (CS2000-KP08, CS2000) • Algorithm Design (CS3000-KP04, CS3000)			
Responsible for this module: <ul> <li>Prof. Dr. Rüdiger Reischuk</li> </ul> <li>Teacher: <ul> <li>Institute for Theoretical Computer S</li> <li>Prof. Dr. Rüdiger Reischuk</li> <li>Prof. Dr. rer. nat. Till Tantau</li> <li>Prof. Dr. Maciej Liskiewicz</li> </ul> </li> <li>Literature: <ul> <li>Aho, Hopcroft, Ullman: Design and A</li> <li>Cormen, Leiserson, Rivest, Stein: Intri <ul> <li>Mitzenmacher Linfal: Probability and</li> </ul> </li> </ul></li>	cience Analysis of Computer Algori roduction to Algorithms - Th	thms - Addison Wesley, 19 ne MIT Press, 2009	78
<ul> <li>Kreher, Stinson: Combinatorial Algo</li> <li>Williamson, Shmoys: The Design of A</li> </ul>	<ul> <li>Weiler, Sunson, Combinational Algorithms - Cric Press, 1999</li> <li>Williamson, Shmoys: The Design of Approximation Algorithms - Cambridge University Press, 2011</li> </ul>		



### Language:

# German and English skills required

### Notes:

Admission requirements for taking the module:

- None (the competencies of the modules listed under

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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 (opt Master Entrepreneurship in Digital Master Computer Science 2019 (ba Master Medical Informatics 2019 (o Master IT-Security 2019 (compulsor Master Medical Informatics 2014 (b Master Media Informatics 2014 (opt Master Entrepreneurship in Digital Master Computer Science 2014 (opt Master Computer Science 2014 (ba	tional subject), computer sci Technologies 2020 (advance sic module), Theoretical com ptional subject), Theoretical y), Theoretical computer scie asic module), computer scie tional subject), computer sci Technologies 2014 (basic mo tional subject), specializatior sic module), Theoretical com	ence, 3rd semester ed module), specific, Arbitra oputer science, 1st or 2nd so computer science, 1st or 2 ence, 1st or 2nd semester nce, 1st or 2nd semester ence, Arbitrary semester odule), technology field com n field IT security and safety oputer science, 1st or 2nd so	iry semester emester nd semester mputer science, 1st or 2nd semester y, 2nd or 3rd semester emester		
Classes and lectures:		Workload:			
<ul> <li>Specification and Modelling (lectur</li> <li>Specification and Modelling (exercition)</li> </ul>	e, 2 SWS) se, 2 SWS)	<ul> <li>80 Hours private</li> <li>60 Hours in-class</li> <li>20 Hours exam p</li> <li>20 Hours work or</li> </ul>	studies and exercises room work reparation n project		
Contents of teaching: <ul> <li>Introduction to modelling and specification</li> <li>Modelling concepts (data, streams, traces, diagrams, tables)</li> <li>Modelling software components (state, behaviour, structure, interface)</li> <li>Modelling concurrency</li> <li>Algebraic specification</li> <li>Composing, refining, analysing and transforming specifications and models</li> <li>Specification languages and tools for specification and modelling</li> </ul> Qualification-goals/Competencies: <ul> <li>The students can argue on the importance of specifications and models for software development.</li> <li>They can characterize, apply, adapt and extent important specification and modelling techniques.</li> <li>They can model and specify simple software/hardware system in an adequate way.</li> <li>They can apply specifications and models is of tware development.</li> </ul>					
Grading through:	by the examiner				
Responsible for this module: • Prof. Dr. Martin Leucker Teacher: • Institute of Software Technology ar • Dr. Annette Stümpel • Prof. Dr. Martin Leucker Literature: • V.S. Alagar, K. Periyasamy: Specification and • M. Broy, K. Stølen: Specification and • J. Loeckx, HD. Ehrich, M. Wolf: Specification and	tion of Software Systems - S Development of Interactive cification of Abstract Data T	pringer 2013 e Systems - Springer 2001 ypes - John Wiley & Sons 19	997		
• U. Kastens, H. Kleine Büning: Mode	llierung - Grundlagen und fo	rmale Methoden - Hanser 2	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 a Master MES 2020 (option) Master Entrepreneurship Master Media Informatics Master Computer Science Master Medical Informati Master IT-Security 2019 (I Master MES 2014 (option) Master Medical Informatics Master Media Informatics Master Entrepreneurship Master Computer Science	and term: al subject), computer science / electri in Digital Technologies 2020 (advance 5 2020 (optional subject), computer sci 2 2019 (basic module), technical comp cs 2019 (optional subject), technical co basic module), technical computer sci al subject), computer science / electri cs 2014 (basic module), computer sci 5 2014 (optional subject), computer sci in Digital Technologies 2014 (basic m e 2014 (basic module), technical comp	ical engineering, Arbitrary se red module), specific, Arbitra cience, Arbitrary semester puter science, 1st or 2nd sen computer science, 1st or 2nd ience, 1st or 2nd semester ical engineering, 1st semester ence, 1st or 2nd semester cience, Arbitrary semester nodule), specific, 1st or 2nd sen puter science, 1st or 2nd sen	emester iry semester nester I semester er semester nester	
Classes and lectures:		Workload:		
Real-Time Systems (lectures)     Real-Time Systems (exerced)	re, 2 SWS) :ise, 2 SWS)	<ul> <li>100 Hours private</li> <li>60 Hours in-class</li> <li>20 Hours exam p</li> </ul>	e studies room work reparation	
<ul> <li>Real-time processing (def</li> <li>Process automation syste</li> <li>Real-time programming</li> <li>Process connectivity and</li> <li>Modelling of discrete eve</li> <li>Modelling of continuous</li> <li>Application of design too</li> </ul> Qualification-goals/Competence <ul> <li>The students are able to</li> <li>They are able to explain a</li> <li>They are able to elucidate</li> <li>They are able to model, a</li> </ul>	finitions, requirements) ems networking ent systems (automata, state charts) systems (differential equations, Lapla ols (Matlab/Simulink, Stateflow) cies: describe the fundamental problems of real-time computer systems for proce n real-time systems in the IEC language e process interfaces and real-time bus analyze and implement event discrete	ace transformation) of real-time processing. ess automation, in particular ges. s system. e systems, in particular proce	SPS. ess control systems.	
<ul> <li>They are able to model, a</li> <li>They are able to make us</li> </ul>	inalyze and implement continuous sy e of design tools for real-time system	istems, in particular feedbac is.	k control systems.	
Grading through: • written exam				
Responsible for this module: • Prof. DrIng. Mladen Bere Teacher: • Institute of Computer Eng • Prof. DrIng. Mladen Bere	ekovic gineering ekovic			
Literature: • R. C. Dorf, R. H. Bishop: M • L. Litz: Grundlagen der Au • M. Seitz: Speicherprograr • H. Wörn, U. Brinkschulte: • S. Zacher, M. Reuter: Reg	lodern Control Systems - Prentice Hal utomatisierungstechnik - Oldenbourg nmierbare Steuerungen - Fachbuchve Echtzeitsysteme - Berlin: Springer 200 elungstechnik für Ingenieure - Spring	l 2010 g 2012 erlag Leipzig 2012 05 jer-Vieweg 2014		
<ul> <li>They are able to make us</li> <li>Grading through: <ul> <li>written exam</li> </ul> </li> <li>Responsible for this module: <ul> <li>Prof. DrIng. Mladen Bere</li> </ul> </li> <li>Teacher: <ul> <li>Institute of Computer Eng</li> <li>Prof. DrIng. Mladen Bere</li> </ul> </li> <li>Literature: <ul> <li>R. C. Dorf, R. H. Bishop: M</li> <li>L. Litz: Grundlagen der Au</li> <li>M. Seitz: Speicherprograr</li> <li>H. Wörn, U. Brinkschulte: <ul> <li>S. Zacher, M. Reuter: Reg</li> </ul> </li> </ul></li></ul>	e of design tools for real-time system ekovic gineering ekovic lodern Control Systems - Prentice Hal utomatisierungstechnik - Oldenbourg mmierbare Steuerungen - Fachbuchv Echtzeitsysteme - Berlin: Springer 20 elungstechnik für Ingenieure - Spring	l 2010 g 2012 erlag Leipzig 2012 05 er-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-KP00	5, CS4170SJ14 - Parall	CS4170-KP06, CS4170SJ14 - Parallel Computer Systems (ParaRSys14)				
Duration:	Turnus of offer:		Credit points:			
1 Semester	each winter semester		6			
<ul> <li>Course of study, specific field and term:</li> <li>Certificate in Artificial Intelligence (compulsory), Artificial Intelligence, 1st semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (basic module), technical computer science, 1st or 2nd semester</li> <li>Master Medical Informatics 2019 (optional subject), technical computer science, 1st or 2nd semester</li> <li>Master Robotics and Autonomous Systems 2019 (optional subject), Elective, 1st or 2nd semester</li> <li>Master IT-Security 2019 (basic module), technical computer science, 1st or 2nd semester</li> <li>Master Medical Informatics 2014 (basic module), computer science, 1st or 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (basic module), specific, 1st or 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (basic module), specific, 1st or 2nd semester</li> <li>Master Computer Science 2014 (basic module), technical computer science, 1st or 2nd semester</li> </ul>						
Classes and lectures:		Workload:				
<ul> <li>Parallel Computer Systems (lecture,</li> <li>Parallel Computer Systems (exercise)</li> </ul>	2 SWS) , 2 SWS)	<ul> <li>100 Hours private</li> <li>60 Hours in-class</li> <li>20 Hours exam p</li> </ul>	e studies room work reparation			
<ul> <li>Motivation and limitations for parallel processing</li> <li>Parallel computing models</li> <li>Taxonomy of parallel computers</li> <li>Multi/manycore-systems</li> <li>Graphic Processing Units (GPUs)</li> <li>OpenCL</li> <li>Specification languages</li> <li>Hardware architectures</li> <li>System management of many-core systems</li> </ul> Qualification-goals/Competencies: <ul> <li>Students are able to characterize different parallel computing architectures.</li> <li>They are able to explain models of parallel computing system is best suited for a dedicated problem and how many cores should be used. <ul> <li>They are able to evaluate the pros and cons of different hardware architectures.</li> <li>They are able to write programs for parallel computing systems under considerations of the underlying hardware architecture.</li> </ul></li></ul>						
Grading through: • written exam						
Responsible for this module: • Prof. DrIng. Mladen Berekovic Teacher: • Institute of Computer Engineering • Prof. DrIng. Mladen Berekovic Literature: • G. Bengel, C. Baun, M. Kunze, K. U. S • M. Dubois, M. Annavaram, P. Storett	tucky: Masterkurs Parallele u öm: Parallel Computer Org	und Verteilte Systeme - Vie	weg + Teubner, 2008 versity Press 2012			
<ul> <li>M. Dubois, M. Annavaram, P. Stenstrom: Parallel Computer Organization and Design - University Press 2012</li> <li>B. R. Gaster, L. Howes, D. R. Kaeli, P. Mistry, D. Schaa: Heterogeneous Computing with OpenCL - Elsevier/Morgan Kaufman 2013</li> <li>B. Wilkinson; M. Allen: Parallel Programming - Englewood Cliffs: Pearson 2005</li> <li>J. Jeffers, J. Reinders: Intel Xeon Phi Coprozessor High-Performance Programming - Elsevier/Morgan Kaufman 2013</li> </ul>						



# 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:		Credit points:			
1 Semester	each winter semester		4			
Course of study, specific field and term: • Master Entrepreneurship in Digital Te • Master IT-Security 2019 (module part • Master Computer Science 2019 (mod	<ul> <li>Course of study, specific field and term:</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master IT-Security 2019 (module part), Module part, 1st or 2nd semester</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> </ul>					
Classes and lectures:	Classes and lectures: Workload:					
<ul> <li>Computer-Aided Design of Digital Ci</li> <li>Computer-Aided Design of Digital Ci</li> </ul>	rcuits (lecture, 2 SWS) rcuits (exercise, 1 SWS)	<ul> <li>55 Hours private</li> <li>45 Hours in-class</li> <li>20 Hours exam p</li> </ul>	studies room work reparation			
Contents of teaching:						
<ul> <li>Abstraction levels in circuit design</li> <li>Design cycle and design strategies</li> <li>FPGA architectures</li> <li>Introduction of the hardware description language VHDL</li> <li>Design of standard components in VHDL</li> <li>Circuit design at different abstraction levels</li> <li>Circuit design for synthesis</li> <li>VHDL simulation cycle</li> <li>VHDL circuit design for FPGAs</li> <li>Designing Testbenches</li> <li>High-Level-Synthesis</li> </ul>						
<ul> <li>Qualification-goals/Competencies:</li> <li>Based on a non-formal description of a digital system, students are able to design digital circuits using VHDL</li> <li>They are able to simulate and test VHDL descriptions</li> <li>They are able to explain the internal structures of FPGAs</li> <li>They are able to determine which VHDL construct will result in which circuit structure</li> <li>They are able to explain the VHDL simulation cycle</li> <li>They are able to write synthesizable VHDL code</li> </ul>						
Grading through: • exam type depends on main module						
Responsible for this module: • Prof. DrIng. Mladen Berekovic Teacher: • Institute of Computer Engineering • Prof. DrIng. Mladen Berekovic						
Literature:						
<ul> <li>F. Kesel, R. Bartholomä: Entwurf von</li> <li>C.Maxfield: The Design Warrior's Guid</li> </ul>	digitalen Schaltungen und de to FPGAs - Newnes 2004	Systemen mit HDLs und F I	PGAs - Oldenbour Verlag 2009			
<ul> <li>English, except in case of only German-speaking participants</li> </ul>						
Notes:						
Admission requirements for taking the - None	module:					



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 (n Master Entrepreneurship in Digita Master IT-Security 2019 (module p Master Entrepreneurship in Digita Master Computer Science 2014 (n	: nodule part), Module part, Ar l Technologies 2020 (module part), Module part, 1st or 2nd l Technologies 2014 (module nodule part), Module part, Ar	bitrary semester e part), Module part, Arbitra semester e part), Module part, Arbitra bitrary semester	ry semester ry semester	
Classes and lectures:		Workload:		
<ul> <li>Mobile und verteilte Datenbanker</li> <li>Mobile und verteilte Datenbanker</li> </ul>	<ul> <li>Mobile und verteilte Datenbanken (lecture, 2 SWS)</li> <li>Mobile und verteilte Datenbanken (exercise, 1 SWS)</li> <li>Mobile und verteilte Datenbanken (exercise, 1 SWS)</li> <li>Hours exam preparation</li> </ul>			
Contents of teaching:				
<ul> <li>The contents of the lecture covers query processing, transactions and replication in</li> <li>- centralised database management systems</li> <li>- parallel database management systems</li> <li>- distributed database management systems</li> <li>- mobile database management systems</li> <li>- mobile database management systems</li> <li>Students can explain the differences between centralised, parallel, distributed and mobile database management systems.</li> <li>They can judge about the practical suitability of different synchronization approaches for distributed and mobile transactions for a given problem.</li> </ul>				
<ul> <li>They can choose suitable replication</li> <li>They can recognize and deal with</li> <li>Grading through:</li> </ul>	ion approaches for a given a the special difficulties and s	oplication and justify their c ources of error in distributed	hoices. d and mobile environments.	
exam type depends on main mod	uie			
Responsible for this module:         • Siehe Hauptmodul         Teacher:         • Institute of Information Systems         • Prof. Dr. Sven Groppe				
······				
<ul> <li>A. Kemper, A. Eickler: Datenbanksysteme - 2006</li> <li>T. Conolly, C. Begg: Database Systems - A Practical Approach to Design, Implementation, and Management - Addison-Wesley 2005</li> <li>E. Rahm: Mehrrechner-Datenbanksysteme - Addison-Wesley 1994</li> <li>P. Dadam: Verteilte Datenbanken und Client/Server Systeme - Springer 1996</li> <li>H. Höpfner, C. Türker, B. König-Ries: Mobile Datenbanken und Informationssysteme - dpunkt.verlag 2005</li> <li>B. Mutschler, G. Specht: Mobile Datenbanksysteme - Springer 2004</li> <li>V. Kumar: Mobile Database Systems - Wiley-Interscience 2006</li> </ul>				
Language:				
<ul> <li>offered only in German</li> </ul>				
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





CS4151 T - Module part: Architectures for Distributed Applications (SVAa)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		4		
<ul> <li>Course of study, specific field and term:</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master IT-Security 2019 (module part), Module part, 1st or 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Computer Science 2014 (module part), Module part, Arbitrary semester</li> </ul>					
Classes and lectures: • Architectures for Distributed Applica • Architectures for Distributed Applica	Classes and lectures:       Workload:         • Architectures for Distributed Applications (lecture, 2 SWS)       • 45 Hours in-classroom work         • Architectures for Distributed Applications (lecture, 2 SWS)       • 45 Hours in-classroom work				
	. ,	• 30 Hours exam p	reparation		
<ul> <li>Contents of teaching:</li> <li>Motivation</li> <li>Software Architectures</li> <li>Basics: HTTP, XML &amp; Co</li> <li>N-Tier Applications</li> <li>Service-Oriented and Event-Driven Architectures (SOA and EDA)</li> <li>Web-Oriented Architectures (Web 2.0)</li> <li>Overlay Networks</li> <li>Peer-to-Peer</li> <li>Grid and Cloud Computing</li> <li>Internet of Things</li> </ul>					
<ul> <li>Qualification-goals/Competencies:</li> <li>The students are able to name the most important archiectures for distributed systems, explain them, and compare them to each other.</li> <li>For each architecture, they know the most prominent and important implementation platforms and basically know how to use them.</li> <li>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.</li> </ul>					
Grading through: <ul> <li>exam type depends on main module</li> </ul>					
Responsible for this module: • Prof. DrIng Horst Hellbrück Teacher: • Institute of Telematics • Prof. DrIng 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



CS4220 T - Module part: Pattern Recognition (MEa)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	not available anymore		4		
<ul> <li>Course of study, specific field and term:</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master IT-Security 2019 (module part), Module part, 1st or 2nd semester</li> <li>Master Computer Science 2014 (module part), advanced curriculum, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master MES 2014 (module part), computer science / electrical engineering, 1st semester</li> <li>Master Computer Science 2014 (Module part of a compulsory module) specialization field robotics and automation. Arbitrary semester</li> </ul>					
Classes and lectures:		Workload:			
<ul> <li>Pattern Recognition (lecture, 2 SWS)</li> <li>Pattern Recognition (exercise, 1 SWS)</li> </ul>	)	<ul> <li>55 Hours private</li> <li>45 Hours in-classi</li> <li>20 Hours exam private</li> </ul>	studies room work reparation		
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 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					
<ul> <li>They are able to explain the basic ele</li> <li>They are able to use feature extraction</li> </ul>	ements of statistical modeli on, feature reduction and p	ng. attern classification technic	ques in practice.		
Grading through:					
exam type depends on main module	2				
Responsible for this module:   • Prof. DrIng. Alfred Mertins  Teacher:  • Institute for Signal Processing  • Prof. DrIng. Alfred Mertins					
Literature: • R. O. Duda, P. E. Hart, D. G. Storck: Pa	ttern Classification - New Y	ork: 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:					
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2023 (module part), advanced curriculum, 2nd semester</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master MES 2020 (module part), computer science / electrical engineering, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master Medical Informatics 2019 (module part), Module part, Arbitrary semester</li> <li>Master Biophysics 2019 (module part), advanced curriculum, 2nd semester</li> <li>Master Biophysics 2019 (module part), advanced curriculum, 2nd semester</li> <li>Master IT-Security 2019 (module part), Module part, 1st or 2nd semester</li> <li>Master Medical Informatics 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part, Arbitrary semester</li> <li>Master Medical Informatics 2014 (module part), Module part, Arbitrary semester</li> <li>Master Medical Informatics 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master MES 2014 (module part), computer science / electrical engineering, 2nd semester</li> </ul>					
Classes and lectures:		Workload:			
<ul> <li>NeuroInformatics (lecture, 2 SWS)</li> <li>NeuroInformatics (exercise, 1 SWS)</li> </ul>		<ul> <li>55 Hours private</li> <li>45 Hours in-class</li> <li>20 Hours exam p</li> </ul>	studies room work reparation		
Contents of teaching:					
<ul> <li>The human brain and abstract neurors</li> <li>Learning with a single neuron:* Perconstruction</li> <li>Network architectures:* Hopfield-Ne</li> <li>Unxupervised Learning:* k-means, N</li> <li>Qualification-goals/Competencies:</li> <li>The students are able to understand</li> <li>They know abstract neuronal model</li> </ul>	<ul> <li>The human brain and abstract neuron models</li> <li>Learning with a single neuron:* Perceptrons* Max-Margin Classification* LDA and logistic Regression</li> <li>Network architectures:* Hopfield-Networks* Multilayer-Perceptrons* Deep Learning</li> <li>Unxupervised Learning:* k-means, Neural Gas and SOMs* PCA &amp; ICA* Sparse Coding</li> </ul> Qualification-goals/Competencies: <ul> <li>The students are able to understand the principle function of a single neuron and the brain as a whole.</li> </ul>				
<ul><li>They are able to derive a learning ru</li><li>They are able to apply (and implement)</li></ul>	le from a given error functi ent) the proposed learning	on. rules and approaches to so	lve unknown practical problems.		
Grading through:					
<ul> <li>exam type depends on main module</li> </ul>	2				
Responsible for this module:					
<ul> <li>Siehe Hauptmodul</li> </ul>					
Teacher:					
Institute for Neuro- and Bioinformati	CS				
Prof. Dr. rer. nat. Thomas Martinetz					
Literature: • S. Haykin: Neural Networks - London • J. Hertz, A. Krogh, R. Palmer: Introdu • T. Kohonen: Self-Organizing Maps - I • H. Ritter, T. Martinetz, K. Schulten: No Addison Wesley, 1991	: Prentice Hall, 1999 ction to the Theory of Neur Berlin: Springer, 1995 euronale Netze: Eine Einfüh	al Computation - Addison <sup>1</sup> Irung in die Neuroinformat	Wesley, 1991 ik selbstorganisierender Netzwerke - Bonn:		
Languago.					
• 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)



CS4	670 T - Module part: An	nbient Computing (An	nbCompa)	
Duration:	Turnus of offer: Credit points:			
1 Semester	each summer semester	each summer semester		
Course of study, specific field and te Master Computer Science 2019 Master Entrepreneurship in Dig Master IT-Security 2019 (modu Master Entrepreneurship in Dig Master Computer Science 2014	e <b>rm:</b> 9 (module part), Module part, A gital Technologies 2020 (modu le part), Module part, 1st or 2n gital Technologies 2014 (modu 4 (module part), Module part, A	Arbitrary semester le part), Module part, Arbitr d semester le part), Module part, Arbitr Arbitrary semester	ary semester ary semester	
Classes and lectures:		Workload:		
• Ambient Computing (lecture, 3	Ambient Computing (lecture, 3 SWS)     Solution     Solution			
Contents of teaching:				
<ul> <li>Smart components</li> <li>Software architectures</li> <li>Context-sensitive systems</li> <li>Ambient Intelligence</li> <li>Interactive ambient media syst</li> <li>Ambient Computing Application</li> <li>Ethical, Legal and Social Implication</li> <li>Qualification-goals/Competencies:</li> <li>The students are able to evalu</li> <li>They have an overview about -</li> </ul>	tems ons (AAL) ations (ELSI). ate possibilities, concepts and current technologies and syste	challenges of Ambient Syste ms for developing Ambient	ems Systems	
Grading through: • exam type depends on main n	nodule			
<ul> <li>Siehe Hauptmodul</li> <li>Teacher:         <ul> <li>Institute of Telematics</li> <li>Prof. DrIng. Andreas Schrader</li> </ul> </li> </ul>				
Literature:				
<ul> <li>John Krumm: Ubiquitous Com</li> <li>Stefan Poslad: Ubiquitous Com</li> <li>Uwe Hansman et al: Pervasive</li> </ul>	puting Fundamentals - CRC Pre nputing: Smart Devices, Enviror Computing - Springer, 2003	ess, 2009 nments and Interactions - W	iley, 2009	
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



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 (I • Master IT-Security 2019 (module pa • Master Computer Science 2019 (mod • Master Entrepreneurship in Digital • Master Entrepreneurship in Digital • Master Computer Science 2014 (mod	Module part of a compulsory rt), Module part, 1st or 2nd s idule part), Module part, Arb Fechnologies 2020 (module Fechnologies 2014 (module idule part), Module part, Arb	/ module), Module part, 1st semester itrary semester part), Module part, Arbitrar part), Module part, Arbitrar itrary semester	t semester ry semester ry semester
Classes and lectures:		Workload:	
<ul> <li>Web-Mining Agents (lecture, 4 SWS</li> <li>Web-Mining Agents (exercise, 1 SW</li> <li>Web-Mining Agents (practical course)</li> </ul>	<ul> <li>(5)</li> <li>120 Hours private studies</li> <li>WS)</li> <li>90 Hours in-classroom work</li> <li>30 Hours exam preparation</li> </ul>		e studies room work reparation
<ul> <li>Probabilities and generative model</li> <li>Gaussian models, Bayesian and free</li> <li>Probabilistic graphical models (e.g., MAP, ML, EM algorithm), probabilis</li> <li>Probabilistic reasoning over time (c problems: filtering, prediction, smo approximations, learning dynamic l</li> <li>Structural Causal Networks (Interve</li> <li>Mixture models, latent linear mode</li> <li>Decision making under uncertainty iteration, policy iteration, MDPs, de decision networks)</li> <li>Game theory, decisions with multip Arrow's Theorem, mechanism desig</li> <li>Building and exchanging symbolic</li> <li>Information association, retrieval, q</li> </ul>	s for discrete data juentist statistics, regression Bayesian networks), learnin tic classification, probabilisti lynamic Bayesian networks, othing, most-likely explanati Bayesian networks) ntion, instrumental Variables (LDA, LSI, PCA), sparse line (utility theory, decision networks) resion-theoretic agents, PON of agents (Nash equilibrium, on (controlled autonomy), ru annotations for web data (fr uery answering and recomm	, g parameters and structure c relational models Markov assumption, transit ion, hidden Markov models s, counterfactuals) ear models, works, value of information 1DPs, reduction to multidin , Bayes-Nash equilibrium), s les of encounter om named entity recogniti mendation	es of probabilistic graphical models (BME, tion model, sensor model, inference s, Kalman filters, exact inferences and n, sequential decision problems, value nensional continuous MDPs, dynamic social choice (voting, preferences, paradoxes, ion to discourse representations) ion to discourse representations)
<ul> <li>Qualification-goals/Competencies:</li> <li>Knowledge:Students can explain the mining agents (goals, utilities, envir cooperation can be discussed in ter real-world scenarios, students can s formalism in static and dynamic set settings, with and with complete ac (partially observable) Markov decisi identify techniques for simultaneou Students can explain coordination choice functions, voting protocol, a model-based learning approaches, either on the basis of static data, or suitable representation formalisms.</li> </ul>	e agent abstraction, define v conments). They can describe ms of decision problems and summarize how Bayesian net tings. In addition, students of ccess to the state of the envi on problems, and they can r is localization and mapping, problems and decision maki nd mechanism design techr and they can enumerate bas on the basis of incrementall and they explain how axion	web mining of rational beh e the main features of envi d algorithms for solving the tworks can be employed as can define decision making ronment. In this context, st recall techniques for measu and can explain planning f ng in a multi-agent setting niques.Students can explair sic machine learning techn ly incoming data . For deali	avior, and give details about the design of ronments. The notion of adversarial agent ese problems. For dealing with uncertainty in s a knowledge representation and reasoning procedures in simple and sequential tudents can describe techniques for solving uring the value of information. Students can techniques for achieving desired states. in term of different types of equilibria, social in the difference between instance-based and ique for each of the two basic approaches, ing with uncertainty, students can describe r structures used in these formalisms can be

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

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



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.

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### 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 a • Master Computer Science • Master Entrepreneurship • Master IT-Security 2019 (n • Master Entrepreneurship • Master Computer Science	and term: e 2019 (module part), Module part, Ar in Digital Technologies 2020 (module module part), Module part, 1st or 2nd in Digital Technologies 2014 (module e 2014 (module part), Module part, Ar	pitrary semester part), Module part, Arbitrary semester semester part), Module part, Arbitrary semester bitrary semester				
Classes and lectures:Workload:• Semantic Web (lecture, 2 SWS)• 65 Hours private studies• Semantic Web (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation						
Contents of teaching: Introduction with overvie Data management for Se Query processing for Sen Processing strategies for	<ul> <li>Contents of teaching:</li> <li>Introduction with overview of the W3C Semantic Web family of languages</li> <li>Data management for Semantic Web data, in particular indexing approaches</li> <li>Query processing for Semantic Web queries (central, parallel, and distributed, in particular in the cloud)</li> <li>Processing strategies for Semantic Web rules and ontologies</li> </ul>					
<ul> <li>Qualification-goals/Competencies:</li> <li>Students can judge about the possibilities and limits of the Semantic Web.</li> <li>They can evaluate the consequences of the Semantic Web approach for data modelling, adminstration and processing, and finally for applications.</li> <li>They can develop Semantic Web applications.</li> <li>They can explain and apply specialized approaches for Semantic Web databases.</li> <li>They can discuss about open research questions in the area of the Semantic Web.</li> </ul>						
Grading through: <ul> <li>exam type depends on main module</li> </ul>						
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute of Information S • Prof. Dr. Sven Groppe	ystems					
Literature:						
<ul> <li>P. Hitzler, M. Krötzsch, S. Rudolph: Foundations of Semantic Web Technologies - Chapman &amp; Hall / CRC, 2009</li> <li>T. Segaran, J. Taylor, C. Evans: Programming the Semantic Web - O'Reilly, 2009</li> <li>F. Bry, J. Maluszynski: Semantic Techniques for the Web - Springer, 2009</li> <li>J. T. Pollock: Semantic Web for Dummies - Wiley, 2009</li> <li>J. Hebeler, M. Fisher, R. Blace, A. Perez-Lopez, M. Dean: Semantic Web Programming - Wiley, 2009</li> <li>G. Antoniou, F. van Harmelen: A Semantic Web Primer - MIT Press, 2008</li> <li>V. Kashyap, C. Bussler, M. Moran: The Semantic Web - Springer, 2008</li> <li>S. Groppe: Data Management and Query Processing in Semantic Web Databases - Springer, 2011</li> </ul>						
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





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 (mo • Master Entrepreneurship in Digital • Master IT-Security 2019 (module pa • Master Entrepreneurship in Digital • Master Computer Science 2014 (Mo	odule part), Module part, Arbi Technologies 2020 (module p Irt), Module part, 1st or 2nd so Technologies 2014 (module p odule part of a compulsory m	trary semester bart), Module part, Arb emester bart), Module part, Arb odule), Module part, A	itrary semester itrary semester rbitrary semester			
Classes and lectures:		Workload:				
<ul> <li>Organic Computing (lecture, 2 SWS</li> <li>Organic Computing (exercise, 1 SW</li> </ul>	;) (S)	<ul> <li>60 Hours priv</li> <li>45 Hours in-c</li> <li>15 Hours example</li> </ul>	ate studies lassroom work n preparation			
Contents of teaching:						
<ul> <li>Basic principles of Organic Computing</li> <li>Self-organization and emergence</li> <li>Architecture and design of Organic Computing systems</li> <li>Organic Computing for distributed systems</li> <li>Organic Computing in Neuro- and Bionformatics</li> <li>Organic Grid</li> <li>Autonomous Systems</li> </ul>						
Qualification-goals/Competencies:						
<ul> <li>Students are able to utilize the prin</li> <li>They are able to explain the princip</li> <li>They are able to analyze emergence</li> </ul>	ciples of organic computing bles of Organic Computing. e behavior in Organic Compu	on exemplary designs. Iting systems.				
Grading through:						
exam type depends on main module						
Responsible for this module: <ul> <li>Siehe Hauptmodul</li> </ul> Teacher: <ul> <li>Institute of Computer Engineering</li> <li>Dr. rer. nat. Javad Ghofrani</li> </ul>						
Literature:						
<ul> <li>C. Müller-Schloer, H. Schmeck, T. Ungerer: Organic Computing A Paradigm Shift for Complex Systems - Birkhäuser, 2011</li> <li>R. P. Würtz: Organic Computing - Springer, 2008</li> <li>C. Klüver, J. Kluever, J. Schmidt: Modellierung komplexer Prozesse durch naturanaloge Verfahren - Springer Vieweg 2012</li> </ul>						
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 (DISensorNa)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		4	
Course of study, specific field and term: • Master Computer Science 2019 (moo • Master Entrepreneurship in Digital To • Master IT-Security 2019 (module par • Master Computer Science 2014 (Moo • Master Entrepreneurship in Digital To • Master Computer Science 2014 (moo	dule part), Module part, Arb echnologies 2020 (module t), Module part, 1st or 2nd dule part of a compulsory n echnologies 2014 (module dule part), advanced curricu	pitrary semester part), Module part, Arbitrar semester nodule), specialization field part), Module part, Arbitrar ulum, Arbitrary semester	y semester robotics and automation, Arbitrary semester y semester	
		Waldaad		
<ul> <li>Wireless Sensor Networks (lecture, 2 SWS)</li> <li>Wireless Sensor Networks (exercise, 1 SWS)</li> </ul>		<ul> <li>60 Hours private studies</li> <li>45 Hours in-classroom work</li> <li>15 Hours exam preparation</li> </ul>		
Contents of teaching:				
<ul> <li>Basics of Sensor Networks</li> <li>Architecture of Sensor Nodes and Se</li> <li>Identities and addressing</li> <li>Wireless communication</li> <li>Data management and topology con</li> <li>Localization</li> <li>Energy harvesting</li> <li>Applications</li> </ul>	ensor Networks ntrol			
Oualification-goals/Competencies:				
<ul> <li>The students are able to present the</li> <li>They are able to cope with analysis,</li> <li>They are able to interpret and pursu</li> </ul>	potential, benefits and lim design, and evaluation of p e current research activities	itations of sensor networks protocols in sensor network s for sensor networks.	S.	
Grading through:				
• exam type depends on main module	2			
Responsible for this module:				
Siehe Hauptmodul				
Teacher:				
Institute of Computer Engineering				
• Dr. rer. nat. Javad Ghofrani				
Literature: • H. Karl, A. Willig: Protocols and Archi • F. Zhao, L. Guibas: Wireless Sensor N • BC. Renner: Sustained Operation of	tectures of Wireless Sensor etworks - Morgan Kaufmar Sensor Nodes with Energy	Networks, - Wiley, 2005 In, 2004 Harvesters and Supercapa	citors - Books on Demand 2013	
Language:				
<ul> <li>offered only in English</li> </ul>				
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



Duration:       Turnus of offer:         I Semester       every summer semester         Course of study, specific field and term:       • Master Computer Science 2019 (module part), Module part, Ark         • Master Entrepreneurship in Digital Technologies 2020 (module	Credit points: 4	
<ul> <li>Semester every summer semester</li> <li>Course of study, specific field and term:         <ul> <li>Master Computer Science 2019 (module part), Module part, Ark</li> <li>Master Entreprepeurship in Digital Technologies 2020 (module</li> </ul> </li> </ul>	4	
Course of study, specific field and term: • Master Computer Science 2019 (module part), Module part, Ark • Master Entrepreneurship in Digital Technologies 2020 (module		
<ul> <li>Master IT-Security 2019 (module part), Module part, 1st or 2nd</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module</li> <li>Master Computer Science 2014 (module part), Module part, Ark</li> </ul>	itrary semester part), Module part, Arbitrary semester semester part), Module part, Arbitrary semester vitrary semester	
Classes and lectures:	Workload:	
<ul> <li>Advanced Internet Technologies (lecture, 2 SWS)</li> <li>Advanced Internet Technologies (exercise, 1 SWS)</li> </ul>	<ul> <li>60 Hours private studies</li> <li>45 Hours in-classroom work</li> <li>15 Hours exam preparation</li> </ul>	
<ul> <li>Introduction and fundamentals</li> <li>Fundamental Internet design principles</li> <li>Problems of today's Internet architecture</li> <li>Backbone Technologies</li> <li>Mobile Internet</li> <li>IPv6 und related topics</li> <li>Delay Tolerant Networks (DTN)</li> <li>Internet of Services / Internet of Things</li> <li>Peer-To-Peer networks</li> <li>Big Data</li> <li>Goals, architectures, algorithms, and protocols for the future In</li> </ul>	ternet	
<ul> <li>Qualification-goals/Competencies:</li> <li>Understand the fundamental design decisions that have led to</li> <li>Understand the original design goals of the Internet and realized networks</li> <li>Learn about essential, universally valid criteria for the design of etc.)</li> <li>Know technological as well as societal developments that have innovations, mobile communications, )</li> <li>Identify problems of the Internet's architecture and understance</li> <li>Become acquainted with the Future Internet research field and future</li> </ul>	today's Internet architecture e the implications that the emphasis on certain of them has on today's networks and applications (e.g., end-to-end argument, fate sharing, led to massive changes in the Internet's infrastructure (growth, potential solutions by comparing different approaches learn about novel approaches to research and shape the Internet of the	
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 • Athanasios V. Vasilakos, Yan Zhang, Thrasyvoulos Spyropoulos: • E. Pacitti, R. Akbarinia, M. El-Dick: P2P Techniques for Decentral	of Things: Key Applications and Protocols - Wiley, 2012 Delay Tolerant Networks: Protocols and Applications - CRC Press, 2012 ized Applications - Morgan & Claypool Publishers	



### 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


CS5170 T - Module part: Hardware/Software Co-Design (HWSWCoda)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		4	
<ul> <li>Course of study, specific field and term:</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master IT-Security 2019 (module part), Module part, 1st or 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Computer Science 2014 (module part), Module part, Arbitrary semester</li> </ul>				
Classes and lectures:		Workload:		
<ul> <li>Hardware/Software Co-Design (lectu</li> <li>Hardware/Software Co-Design (exer</li> </ul>	<ul> <li>Hardware/Software Co-Design (lecture, 2 SWS)</li> <li>Hardware/Software Co-Design (exercise, 1 SWS)</li> <li>Hardware/Software Co-Design (exercise, 1 SWS)</li> <li>45 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>			
Contents of teaching:				
<ul> <li>Basic architectures for HW/SW systems</li> <li>System design and modelling</li> <li>System synthesis</li> <li>Algorithms for scheduling</li> <li>System partitioning</li> <li>Algorithms for system partitioning</li> <li>Design systems</li> <li>Performance analysis</li> <li>System design and specification with SystemC</li> <li>Application examples</li> </ul>				
<ul> <li>Qualification-goals/Competencies:</li> <li>Students are able to determine a suitable hardware/software architecture for a given system description</li> <li>They are able to determine and describe the pros and cons of implementation alternatives</li> <li>They are able to apply methods for system partitioning</li> <li>They are able to translate non-formal system descriptions into formal models</li> <li>They are able to explain the different steps in system synthesis</li> <li>They are able to create system descriptions in SystemC</li> </ul>				
Responsible for this module:				
Siehe Hauptmodul	Siehe Hauptmodul			
Teacher:     Institute of Computer Engineering				
Prof. DrIng. Mladen Berekovic				
literature:				
<ul> <li>F. Kesel: Modellierung von digitalen Systemen mit SystemC - Oldenbourg Verlag 2012</li> <li>Teich, J., Haubelt, C.: Digital Hardware/Software-Systeme. Synthese und Optimierung - Berlin: Springer 2007</li> </ul>				
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



Duration:	Turnus of offer:	Credit points:	
Semester	every second semester	4 (Тур В)	
Course of study, specific field Master Biophysics 2023 Master Computer Scier Master MES 2020 (mod Master Entrepreneursh Master Biophysics 2019 Master IT-Security 2019 Master MES 2014 (mod Master Entrepreneursh Master Computer Scier	d and term: 3 (module part), advanced curriculum, the 2019 (module part), Module part, A ule part), computer science / electrica ip in Digital Technologies 2020 (modu 0 (module part), advanced curriculum, 0 (module part), Module part, 1st or 2n ule part), computer science / electrica ip in Digital Technologies 2014 (modu the 2014 (module part), Module part, A	1st or 2nd semester Arbitrary semester engineering, Arbitrary semester le part), Module part, Arbitrary semester 1st or 2nd semester d semester engineering, 1st or 2nd semester le part), Module part, Arbitrary semester Arbitrary semester	
Classes and lectures:		Workload	
iRoom (practical course	and lectures:Workload:Room (practical course, 3 SWS)• 60 Hours group work• 40 Hours private studies• 20 Hours written report		
Contents of teaching: • Planning and realizatio	n of typical signal processing applicat	ions in a team	
<ul> <li>Students will have com</li> <li>They are able to realize</li> <li>They have the communication</li> </ul>	nprehensive knowledge of using signa e signal processing systems in teamwo nication competency to document and	l and image processing algorithms in practice. rk and in a self-directed manner. I present project results.	
Grading through: • exam type depends on	main module		
Requires: • Signal processing (CS3 • Image processing (CS3	100-КР04) 203)		
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute for Signal Proc • Prof. DrIng. Markus Ka • MitarbeiterInnen des	: : : : : : : : : : : : : : : : : : :		
Language: • offered only in German			
Noto:			
(Part of Module CS4510)			
Prerequisites for attendin - None	g the module:		
Prerequisites for the exar - The project must be cor	n: npleted in order to take the exam in tl	ne module CS4510	
Modul Exam: - CS4510-L1: Signal Analy	rsis, oral exam consisting out of Patteri	n Recognition, Selected Topics of Signal Analysis and Enhancement and	



L

this project, 100% of module grade



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CS5260SJ14 T - Module part: Speech and Audio Signal Processing (SprachA14a)				
Duration:	Turnus of offer: Credit points:			
1 Semester	emester normally each year in the summer semester 4			
<ul> <li>Course of study, specific field and term:</li> <li>Master Computer Science 2019 (module part), Module part, Arbitrary semester</li> <li>Master Biophysics 2023 (module part), advanced curriculum, 1st and 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (module part), Module part, Arbitrary semester</li> <li>Master Biophysics 2019 (module part), advanced curriculum, 1st or 2nd semester</li> <li>Master IT-Security 2019 (module part), Module part, Arbitrary semester</li> <li>Master Computer Science 2014 (Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part, Arbitrary semester</li> <li>Master Computer Science 2014 (Module part of a compulsory module), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (module part), Module part, Arbitrary semester</li> </ul>				
Classes and lectures:		Workload:		
<ul> <li>Speech and Audio Signal Processing</li> <li>Speech and Audio Signal Processing</li> </ul>	<ul> <li>Speech and Audio Signal Processing (lecture, 2 SWS)</li> <li>Speech and Audio Signal Processing (exercise, 1 SWS)</li> <li>Speech and Audio Signal Processing (exercise, 1 SWS)</li> <li>45 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>			
Contents of teaching: <ul> <li>Speech production and human hearing</li> <li>Physical models of the auditory System</li> <li>Dynamic compression</li> <li>Spectral analysis: Spectrum and Cepstrum</li> <li>Spectral perception and masking</li> <li>Vocal tract models</li> <li>Linear prediction</li> <li>Coding in time and frequency domains</li> <li>Speech synthesis</li> <li>Noise reduction and echo compensation</li> <li>Source localization and spatial reproduction</li> <li>Basics of automatic speech recognition</li> </ul>				
<ul> <li>Qualification-goals/Competencies:</li> <li>Students are able to describe the basics of human speech production and the corresponding mathematical models.</li> <li>They are able to describe the process of human auditory perception and the corresponding signal processing tools for mimicing auditory perception.</li> <li>They are able to present basic knowledge of statistical speech modeling and automatic speech recognition.</li> <li>They can describe and use signal processing methods for source separation and room-acoustic measurements.</li> </ul>				
Grading through: • exam type depends on main module	2			
Responsible for this module:         • Siehe Hauptmodul         Teacher:         • Institute for Signal Processing         • Prof. DrIng. Markus Kallinger				
<ul> <li>Literature:</li> <li>L. Rabiner, BH. Juang: Fundamentals of Speech Recognition - Upper Saddle River: Prentice Hall 1993</li> <li>J. O. Heller, J. L. Hansen, J. G. Proakis: Discrete-Time Processing of Speech Signals - IEEE Press</li> </ul>				
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 par	t: Selected Topics of S	Signal Analysis and E	nhancement (AMSAVa)
Duration:	Turnus of offer:		Credit points:
1 Semester	each summer semester		4
Course of study, specific field and term: Master Robotics and Autonomous Syst Master Biophysics 2023 (module part Master Computer Science 2019 (mod Master MES 2020 (module part), com Master Entrepreneurship in Digital Te Master Biophysics 2019 (module part Master IT-Security 2019 (module part Master Entrepreneurship in Digital Te Master Entrepreneurship in Digital Te Master MES 2014 (module part), com Master Computer Science 2014 (mod	ems 2019 (module part), Mo c), advanced curriculum, 2nd lule part), Module part, Arbi puter science / electrical er echnologies 2020 (module p c), advanced curriculum, 2nd c), Module part, 1st or 2nd s echnologies 2014 (module p puter science / electrical er lule part), Module part, Arbi	dule part Current Issues Rob d semester itrary semester igineering, Arbitrary semes part), Module part, Arbitrar d semester emester part), Module part, Arbitrar igineering, 1st or 2nd seme itrary semester	potics and Automation, 1st and/or 2nd semester ster y semester y semester ester
Classes and lectures:		Workload:	
<ul> <li>Selected Topics of Signal Analysis an SWS)</li> <li>Selected Topics of Signal Analysis an 1 SWS)</li> </ul>	d Enhancement (lecture, 2 d Enhancement (exercise,	<ul> <li>55 Hours private</li> <li>45 Hours in-classi</li> <li>20 Hours exam private</li> </ul>	studies room work reparation
Contents of teaching:			
<ul> <li>Linear optimal filters</li> <li>Adaptive filters</li> <li>Multichannel signal processing, bear</li> <li>Compressed sensing</li> <li>Basic concepts of multirate signal processing algorithm</li> <li>Nonlinear signal processing algorithm</li> <li>Application scenarios in auditory tec measurement, noise reduction, deco</li> </ul>	nforming, and source separ ocessing ns hnology, enhancement, and nvolution (listening-room c	ation d restauration of one- and compensation), inpainting	higher-dimensional signals, Sound-field
Qualification-goals/Competencies:			
<ul> <li>Students are able to explain the basic elements of stochastic signal processing and optimum filtering.</li> <li>They are able to describe and apply linear estimation theory.</li> <li>Students are able to describe the concepts of adaptive signal processing.</li> <li>They are able to describe and apply the concepts of multichannel signal processing.</li> <li>They are able to describe the concept of compressed sensing.</li> <li>They are able to analyze and design multirate systems.</li> <li>Students are able to explain various applications of nonlinear and adaptive signal processing.</li> <li>They are able to create and implement linear optimum filters and nonlinear signal enhancement techniques on their own.</li> </ul>			
Grading through:			
exam type depends on main module			
Responsible for this module: <ul> <li>Siehe Hauptmodul</li> </ul> Teacher: <ul> <li>Institute for Signal Processing</li> <li>Prof. DrIng. Markus Kallinger</li> </ul>			
Literature:			
• A. Mertins: Signaltheorie: Grundlager	n der Signalbeschreibung, F	ilterbänke, 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: Semina	r Machine Learning (SemMaschLa)
Duration:	Turnus of offer:	Credit points:
1 Semester	1 Semester each summer semester 4	
Course of study, specific fie • Master Biophysics 202 • Master Computer Scie • Master MES 2020 (mo	Id and term: 23 (module part), advanced curriculum, 2 ence 2019 (module part), Module part, Ar dule part), computer science / electrical e	nd semester bitrary semester engineering, Arbitrary semester
<ul> <li>Master Entrepreneursi</li> <li>Master Biophysics 201</li> <li>Master IT-Security 201</li> <li>Master MES 2014 (mo</li> <li>Master Entrepreneursi</li> <li>Master Computer Scie</li> </ul>	hip in Digital Technologies 2020 (module 9 (module part), advanced curriculum, 2 9 (module part), Module part, 1st or 2nd dule part), computer science / electrical hip in Digital Technologies 2014 (module ence 2014 (module part), Module part, Ar	e part), Module part, Arbitrary semester nd semester semester engineering, 1st or 2nd semester e part), Module part, Arbitrary semester bitrary semester
Classes and lectures:	·····	Workload:
Seminar Machine Lear	eminar Machine Learning (seminar, 2 SWS) • 70 Hours private studies • 30 Hours in-classroom work • 20 Hours work on an individual topic with written an presentation	
Contents of teaching: • Independent study of	a specific field of machine learning	
Qualification-goals/Compet • Students can read and • Students can present	t <b>encies:</b> d understand scientific articles in the field the contents of scientific articles in the fi	d of machine learning. ield of machine learning in a talk.
Grading through: • exam type depends o	n main module	
Responsible for this module	e:	
Siehe Hauptmodul		
Institute for Neuro- an	nd Bioinformatics	
<ul> <li>Prof. DrIng. Erhardt E</li> <li>MitarbeiterInnen des</li> </ul>	Barth 5 Instituts	
Language: • German and English s	kills required	
Notes: Admission requirements - None	s for the module:	
Admission requirements - Examination prerequis completed and positive	s for the examination: ites may be defined at the beginning of ly evaluated prior to the initial examinati	the semester. If prerequisites are defined, they must have been on.
l (Is part of the module C	S4511)	





	CS5450 T - Module part: Ma	achine Learning (Masch	iLerna)
Duration:	Turnus of offer:	1	Credit points:
1 Semester	Semester each winter semester		4
Course of study, specific field ar Master Biophysics 2023 (m Master Computer Science Master MES 2020 (module Master Entrepreneurship in Master Biophysics 2019 (m Master IT-Security 2019 (m Master Entrepreneurship in Master MES 2014 (module Master Computer Science	nd term: odule part), advanced curriculum, 1 2019 (module part), Module part, An part), computer science / electrical n Digital Technologies 2020 (module odule part), advanced curriculum, 1 odule part), Module part, 1st or 2nc n Digital Technologies 2014 (module part), computer science / electrical 2014 (module part), Module part, An	st semester bitrary semester engineering, Arbitrary semest e part), Module part, Arbitrary st semester e part), Module part, Arbitrary engineering, 1st or 2nd seme bitrary semester	ter r semester r semester ster
Classes and lectures:		Workload:	
<ul> <li>Machine Learning (lecture</li> <li>Machine Learning (exercis</li> </ul>	, 2 SWS) e, 1 SWS)	<ul> <li>55 Hours private st</li> <li>45 Hours in-classro</li> <li>20 Hours exam pression</li> </ul>	tudies oom work eparation
<ul> <li>Representation learning, in</li> <li>Statistical learning theory</li> <li>VC dimension and suppor</li> <li>Boosting</li> <li>Deep learning</li> <li>Limits of induction and im</li> </ul> Qualification-goals/Competencian <ul> <li>Students can understand and apple</li> <li>They can explain and apple</li> <li>They can understand and</li> </ul>	ncluding manifold learning t vector machines portance of data ponderation <b>es:</b> and explain various machine-learnin y different machine learning metho evaluate an appropriate method for explain the limits of automatic data	g problems. ds and algorithms. a particular learning problem analysis.	I.
<ul><li>Grading through:</li><li>exam type depends on main module</li></ul>			
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute for Neuro- and Bi • Prof. DrIng. Erhardt Barth • Prof. Dr. rer. nat. Thomas N	pinformatics 1artinetz		
Literature: • Chris Bishop: Pattern Reco • Vladimir Vapnik: Statistical • Tom Mitchell: Machine Lea	gnition and Machine Learning - Spr Learning Theory - Wiley-Intersciend Irning - McGraw Hill. ISBN 0-07-0428	inger ISBN 0-387-31073-8 :e, ISBN 0471030031 307-7	
Language: • English, except in case of c	<ul> <li>Language:</li> <li>English, except in case of only German-speaking participants</li> </ul>		
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 a • Master IT-Security 2019 (or	ı <b>nd term:</b> optional subject), IT-Security, 3rd seme	ster		
Classes and lectures: • Development of a secure	Classes and lectures:       Workload:         • Development of a secure IT application (practical course, 14       • 290 Hours work on project			
SWS)	SWS)• 120 Hours private studies and exercises• 40 Hours written report• 30 Hours oral presentation (including preparation)			
Contents of teaching:				
<ul> <li>Project task for a concret</li> <li>Analysis of a safety-critica</li> <li>Selection, clear definition</li> <li>Writing of an exposé out</li> </ul>	e safety-critical problem in the IT area al problem in the IT area, including scie and development of methods to incr lining the problem, project task, work	entific state of the art ease safety packages and time managment. Se	lection of adequate tools (e.g. time-,	
<ul><li>task- and progress contro</li><li>Prototypical realization o</li><li>Social, ethical and legal a</li></ul>	n) f a system with given security requirer spects of safety-critical systems (e.g. li	nents while regarding product life ( censing)	cycle and economic efficiency	
Qualification-goals/Competen	cies:			
<ul> <li>The students can recogni</li> <li>The students can analyze</li> <li>The students can assess e</li> <li>The students have basic e</li> </ul>	ze, analyze and realize safety requiren complex IT security tasks and work or economic, social and legal framework competencies in project management	nents. In them in a structured way. conditions in the development of IT , can organize themselves as a proje	systems. ect 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 t	Grading through: <ul> <li>Written report</li> <li>Oral presentation</li> <li>successful addressing of the project goals</li> </ul>			
Responsible for this module:				
Prof. DrIng. Thomas Eise	nbarth			
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):				
- Documentation and (inter	im) presentation as specified when th	e 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 sp	ocific field and term:		
Master IT-Sec	urity 2019 (optional subject), IT-Security, 3rd	semester	
Classes and lecture	s:	Workload:	
<ul> <li>Development of a secure IT application (lecture, 7 SWS)</li> <li>170 Hours work on project</li> <li>60 Hours private studies and exercises</li> <li>40 Hours written report</li> <li>30 Hours oral presentation (including preparation)</li> </ul>			i project :udies and exercises eport entation (including preparation)
Contents of teachin	ıg:		
<ul> <li>Project task for</li> <li>Analysis of a selection, clear</li> <li>Writing of an task- and pro</li> <li>Prototypical resolution</li> <li>Social, ethical</li> </ul>	or a concrete safety-critical problem in the IT safety-critical problem in the IT area, includin ar definition and development of methods to exposé outlining the problem, project task, v gress control) realization of a system with given security rec and legal aspects of safety-critical systems (	area g scientific state of the art o increase safety work packages and time managm quirements while regarding produ e.g. licensing)	ent. Selection of adequate tools (e.g. time-, Ict life cycle and economic efficiency
Qualification-goals,	/Competencies:		
<ul><li>The students</li><li>The students</li><li>The students</li><li>The students</li><li>The students</li><li>In presentation</li></ul>	can recognize, analyze and realize safety req can analyze complex IT security tasks and we can assess economic, social and legal framew have basic competencies in project manager on (of their work), students can respond to sp	uirements. ork on them in a structured way. vork conditions in the developme ment, can organize themselves as pecial audiences or time constraint	nt of IT systems. a project team and apply tools adequatly ts
Grading through:			
<ul> <li>Written repor</li> <li>Oral presenta</li> <li>successful additional</li> </ul>	t tion dressing of the project goals		
Responsible for this	s module:		
Prof. DrIng.	Thomas Eisenbarth		
Teacher:         • Institute for IT	「Security		
Language:			
• English, excep	ot in case of only German-speaking participar	nts	
Notes:			
Admission requ - None	irements for taking the module:		
Admission requ - Successful con - Documentatio	irements for participation in module examinan npletion of the internship task n and (interim) presentation as specified whe	ation(s): en the internship is issued	
Module examin - CS4422-L1: Blo	ation(s): ock internship IT security, project execution, c	locumentation 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-K	P06 - Communicatio	on and System Se	ecurity (KoSyS)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		6
Course of study, specific field and term: • Master Entrepreneurship in Digital Tec • Master MES 2020 (optional subject), co • Master Media Informatics 2020 (option • Master Medical Informatics 2014 (option • Master Medical Informatics 2019 (option • Master IT-Security 2019 (compulsory),	chnologies 2020 (advance omputer science / electric nal subject), computer sc nal subject), computer sc onal subject), ehealth / ir IT-Security, 1st or 2nd se	ed module), specific, cal engineering, Arbit ience, Arbitrary seme ience, Arbitrary seme ifomatics, 1st or 2nd emester	Arbitrary semester rary semester ster ster semester
Classes and lectures.		Workload	
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			
<ul> <li>Cryptographic procedures and protoc</li> <li>IT security at system level, security me</li> <li>Security, privacy and trust of special sy</li> <li>Code analysis</li> <li>Security management, legal framewoi</li> <li>Security problems in IT systems</li> </ul>	rk conditions	d IoT	
Qualification-goals/Competencies: <ul> <li>Students can explain the basic method</li> <li>They can demonstrate a deeper under</li> <li>They can analyze the entire spectrum</li> <li>They can explain modelling technique</li> <li>They can apply a variety of standard t</li> </ul>	ds in the field of cybersed rstanding of cryptograph of the security of a syste es and describe experience echniques to increase the	curity and apply then nic methods and their m. ces with their use. e security of a system	n to case studies. applications in communication systems.
Grading through: • Viva Voce or test • written homework			
Is requisite for: • Current Topics in IT Security (CS5195-ł	<p04)< td=""><td></td><td></td></p04)<>		
Requires:			
<ul> <li>Cybersecurity (CS2250-KP04)</li> <li>Cryptology (CS3420-KP04, CS3420)</li> </ul>			
Responsible for this module:			
Prof. DrIng. Thomas Eisenbarth			
Teacher: • Institute for IT Security			
<ul> <li>Prof. DrIng. Thomas Eisenbarth</li> <li>Prof. Dr. Rüdiger Reischuk</li> <li>Prof. Dr. Esfandiar Mohammadi</li> </ul>			
Literature:			
<ul> <li>Stallings, Brown: Computer Security: P</li> <li>Katz, Lindell: Introduction to Modern (</li> <li>Stinson: Cryptography: Theory and Pr</li> </ul>	Principles and Practice - 4 Cryptography - 2nd ed., C actice - 4th ed., CRC Press	th ed., Pearson, 2018 CRC Press, 2014 s, 2018	



### Language:

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

#### Notes:

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





CS519	5-KP04 - Current Topi	cs 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 (opti • Master IT-Security 2019 (compulsory • Master Robotics and Autonomous Sy	onal subject), Elective, Arbit ), IT-Security, 3rd semester /stems 2019 (optional subje	trary semester ect), Additionally recognized elective module, Arbitrary semester
Classes and lectures:		Workload:
<ul> <li>Current Topics IT Security and Reliab lectures, 2 SWS)</li> <li>Current Topics IT Security and Reliab</li> </ul>	ility (seminar-style ility (project work, 1 SWS)	<ul> <li>45 Hours work on project</li> <li>45 Hours in-classroom work</li> <li>30 Hours private studies and exercises</li> </ul>
Contents of teaching:		
<ul> <li>new results in cyber security</li> <li>design and implementation of a security</li> </ul>	ure system for a complex ap	oplication and its security analysis
Qualification-goals/Competencies: • deeper knowledge of current develo • professional experience of construct	pments in IT security ing and analyzing compute	er systems and networks with respect to security issues
Grading through: • Oral examination		
Responsible for this module:		
Prof. DrIng. Thomas Eisenbarth		
Teacher: Institute for IT Security Institute for Theoretical Computer So Prof. Dr. Maciej Liskiewicz Prof. Dr. Rüdiger Reischuk Prof. DrIng. Thomas Eisenbarth Prof. Dr. Esfandiar Mohammadi	cience	
Literature:		
<ul> <li>papers to be discussed depend on s</li> </ul>	pecific topics: -	
Language: • English, except in case of only Germa	an-speaking participants	
Notes:		
Admission requirements for taking the - None	module:	
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 7	Thesis IT Security (MScITS)			
Duration:	Turnus of offer:	Credit points:			
1 Semester	emester each semester				
Course of study, specific field a • Master IT-Security 2019 (	and term: compulsory), IT-Security, 4th semeste	r			
Classes and lectures:	Classes and lectures: Workload:				
<ul> <li>Master Thesis Media Informatics (supervised self studies, 1 SWS)</li> <li>Colloquium (presentation (incl. preparation), 1 SWS)</li> </ul>		<ul> <li>870 Hours research for and write up of a thesis</li> <li>30 Hours oral presentation and discussion (including preparation)</li> </ul>			
Contents of teaching: • Further qualifications rec	uired are subject to private studies.				
Qualification-goals/Competen • The students can solve a • They elaborate a sophisti • They have expertise they • They are able to analyze, • They possess the commu-	cies: complex scientific problem with the cated scientific work within a given t can apply to problems. interpret and critically assess scientif unication skills to write down and pres	means of their profession. ime. ic literature. sent their scientific results in an appropriate way.			
Grading through: • oral presentation • Written report					
Responsible for this module: <ul> <li>Studiengangsleitung IT-</li> </ul> Teacher: <ul> <li>Institutes of the Departm</li> <li>Alle prüfungsberechtigt</li> </ul>	Sicherheit ent of Computer Science/ Engineerin en Dozentinnen/Dozenten des Studie	g enganges			
Literature: • :					
Language: • thesis can be written in G	ierman or English				
Notes: Admission requirements fo - See study program regula Admission requirements fo - CS5993-L2: see examination Module examination(s): - CS5993-L1 Master thesis I - CS5993-L2 Master thesis I	r taking the module: tions (e.g. certain minimum CP achiev r taking module examination(s): on regulations (e.g. master's thesis as: T Security: master thesis, approx. 67% T-Security: Colloquium, ca 33% of the	ved). sessed with at least sufficient). o of the module grade. module grade			



CS4501-KP12, CS450	01 - Algorithmics, Logi	c and Computationa	l Complexity (ALK14)	
Duration:	Turnus of offer:		Credit points:	
2 Semester	each summer semester		12	
Course of study, specific field and term:				
<ul> <li>Master Entrepreneurship in Digital T</li> <li>Master Computer Science 2019 (opti</li> <li>Master IT-Security 2019 (advanced n</li> <li>Master Entrepreneurship in Digital T</li> <li>Master Computer Science 2014 (advanced n)</li> </ul>	echnologies 2020 (advanced ional subject), advanced mo nodule), Elective Computer S echnologies 2014 (advanced anced module), advanced c	d module), specific, Arbitra dule, Arbitrary semester Science, 1st or 2nd semeste d module), specific, 2nd an urriculum, 2nd and/or 3rd	ry semester er d/or 3rd semester semester	
Classes and lectures:		Workload:		
<ul> <li>Algorithmics, Logic and Computational Complexity (lecture, 4 SWS)</li> <li>Algorithmics, Logic and Computational Complexity (exercise, 2 SWS)</li> <li>Seminar Algorithmics, Logic and Computational Complexity (seminar, 2 SWS)</li> </ul>		<ul> <li>160 Hours private studies and exercises</li> <li>120 Hours in-classroom work</li> <li>40 Hours exam preparation</li> <li>40 Hours work on an individual topic with written and oral presentation</li> </ul>		
Contents of teaching:				
<ul> <li>recent results in algorithmics and co</li> <li>communication and circuit complex</li> <li>structural and descriptive complexit</li> <li>algorithmic game theory</li> <li>nonstandard computing models</li> <li>understanding logics as a tool</li> </ul>	<ul> <li>contents of teaching:</li> <li>recent results in algorithmics and complexity theory</li> <li>communication and circuit complexity</li> <li>structural and descriptive complexity theory</li> <li>algorithmic game theory</li> <li>nonstandard computing models</li> <li>understanding logics as a tool</li> </ul>			
Qualification-goals/Competencies: • the students can demonstrate a dee	n knowledge of concents a	nd methods for algorithm	design and complexity analysis	
<ul> <li>They are able to classify algorithmic</li> <li>They are able to model complex pro</li> <li>They can assess and explain the imp</li> </ul>	problems and to select app blem settings appropriately portance of lower bounds fo	ropriate strategies for their rapplications.	r solution	
Grading through:				
Oral examination				
Requires: • Algorithmics (CS4000-KP06, CS4000	SJ14)			
Responsible for this module:				
Prof. Dr. Kim-Manuel Klein				
Teacher:				
Institute for Theoretical Computer Science				
<ul> <li>Prof. Dr. Rüdiger Reischuk</li> <li>Prof. Dr. rer. nat. Till Tantau</li> <li>Prof. Dr. Maciej Liskiewicz</li> <li>Prof. Dr. Kim-Manuel Klein</li> </ul>				
Literature:				
<ul> <li>R. Reischuk: Einführung in die Komplexitätstheorie - Teubner, 1990</li> <li>S. Arora, B. Barak: Computational Complexity - Cambridge UP 2009</li> <li>C. Papadimitriou: Computational Complexity - Addison-Wesley, 1994</li> <li>M. Huth, M. Ryan: Logic in Computer Science - Cambridge University. Press 2004</li> <li>D. Kozen: Theory of Computation - Springer, 2006</li> </ul>				
Language:				



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# German and English skills required

#### Notes:

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



С\$4503-К	CS4503-KP12, CS4503 - Ambient Computing and Applications (AmbCompA)				
Duration:	Turnus of offer:		Credit points:		
2 Semester	normally each year in t	the summer semester	12		
Course of study, specific field and Master Robotics and Auton Master Entrepreneurship in Master Computer Science 2 Master IT-Security 2019 (ad Master Entrepreneurship in Master Computer Science 2	d term: omous Systems 2019 (advanced Digital Technologies 2020 (advan 019 (optional subject), advanced vanced module), Elective Compu Digital Technologies 2014 (advan 014 (advanced module), advance	module), advanced curriculun nced module), specific, Arbitra module, Arbitrary semester ter Science, 1st or 2nd semest nced module), specific, 2nd ar ed curriculum, 2nd and/or 3rd	n, Arbitrary semester ny semester er nd/or 3rd semester semester		
Classes and lectures:		Workload:			
<ul> <li>CS4670 T: Ambient Computi</li> <li>Seminar Ambient Computit</li> <li>Lab Course Ambient Comp</li> </ul>	<ul> <li>CS4670 T: Ambient Computing (lecture, 3 SWS)</li> <li>Seminar Ambient Computing (seminar, 2 SWS)</li> <li>Lab Course Ambient Computing (project work, 3 SWS)</li> <li>Lab Course Ambient Computing (project work, 3 SWS)</li> <li>20 Hours exam preparation</li> </ul>				
Contents of teaching:					
<ul> <li>Ambient Computing:</li> <li>Current paradigms in computer technology</li> <li>Smart components</li> <li>Software architectures</li> <li>Context-sensitive systems</li> <li>Ambient Intelligence</li> <li>Interactive ambient media systems</li> <li>Ambient Computing Applications (AAL)</li> <li>Ethical, Legal and Social Implications (ELSI)</li> </ul> Qualification-goals/Competencies: <ul> <li>Ambient Computing:</li> <li>The students are able to evaluate possibilities, concepts and challenges of Ambient Systems</li> </ul>					
<ul> <li>They have an overview about current technologies and systems for developing Ambient Systems</li> <li>They are able to follow and judge state-of-the-art research in the area of Ambient Computing</li> </ul>					
Grading through: • portfolio exam					
Responsible for this module:					
Prof. DrIng. Andreas Schrader					
Institute of Telematics					
Prof. DrIng. Andreas Schrader					
Literature:					
<ul> <li>John Krumm: Ubiquitous Co</li> <li>Stefan Poslad: Ubiquitous Co</li> </ul>	omputing Fundamentals - CRC Pr Computing: Smart Devices, Enviro	ress, 2009 onments and Interactions - Wil	ey, 2009		
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%)



C	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 ter Master Entrepreneurship in Dig Master Computer Science 2019 Master Robotics and Autonomo Master IT-Security 2019 (advance Master Entrepreneurship in Dig Master Computer Science 2014	rm: ital Technologies 2020 (advance (optional subject), advanced mo us Systems 2019 (advanced mo red module), Elective Computer ital Technologies 2014 (advanced (advanced module), advanced o	ed module), specific, Arbitra odule, Arbitrary semester dule), advanced curriculum Science, 1st or 2nd semeste ed module), specific, 2nd an curriculum, 2nd and/or 3rd	ary semester n, 1st or 2nd semester er nd/or 3rd semester semester		
Classes and lectures:		Workload			
<ul> <li>Classes and lectures:</li> <li>CS5150 T: Organic Computing (lecture with exercises, 3 SWS)</li> <li>CS5153 T: Wireless Sensor Networks (lecture with exercises, 3 SWS)</li> <li>CS4504-S: Cyber Physical Systems (seminar, 2 SWS)</li> </ul>		<ul> <li>220 Hours private</li> <li>120 Hours in-clas</li> <li>20 Hours exam private</li> </ul>	<ul> <li>• 220 Hours private studies</li> <li>• 120 Hours in-classroom work</li> <li>• 20 Hours exam preparation</li> </ul>		
Contents of teaching:					
<ul> <li>basic principles of organic com</li> <li>from motion to intelligent beha design for self-organization, rol analyzing, reverse-engineering,</li> <li>designing experiments and me</li> <li>modeling system/machine beh</li> <li>complexity, opacity, obscurity, i</li> <li>architecture of organic comput</li> <li>applications of self-x systems</li> <li>basics of wireless sensor netwo</li> <li>hardware aspects of sensor noc</li> <li>physics and protocols of wireles</li> <li>routing in wireless networks</li> <li>time synchronization and locali</li> <li>data management and data pro</li> <li>applications of wireless sensor</li> </ul>	puting / self-x system properties wior and system/machine behavior bustness, adaptivity, flexibility, tr debugging machine behavior asuring behavior avior trust of (AI) systems and explain ing systems rks les ss communication zation in wireless networks pressing in wireless sensor networks hetworks	s vior rust able Al			
Qualification-goals/Competencies: <ul> <li>Students are able to utilize the</li> <li>They are able to explain princip</li> <li>They are able to analyze system</li> <li>Students are able to present th</li> <li>They are able to cope with anal</li> <li>They are able to interpret and p</li> </ul>	principles of organic computing les of organic computing/self-x n/machine behaviors in a structu e pros and cons of sensor netwo ysis, design, and evaluation of p pursue current research activities	J/self-x systems on exempla systems. Ired, sound approach. orks. orotocols in sensor network s for sensor networks.	ary designs. s.		
Caralian athready					
Oral examination					
Responsible for this module: • Prof. DrIng. Mladen Berekovic Teacher: • Institute of Computer Engineeri • Dr. rer. nat. Javad Ghofrani Literature:	ng				
<ul> <li>C. Müller-Schloer, S. Tomforde:</li> <li>H. Karl, A. Willig: Protocols and</li> </ul>	Organic Computing Technical Architectures of Wireless Sensor	Systems for Survival in the Networks - Wiley, 2005	Real World - Birkhäuser, 2017		



### 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)



CS45	05-KP12, CS4505 - Sys	tem Architecture (Sy	sArch)	
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 • Master Computer Science 2019 (opt • Master IT-Security 2019 (advanced r • Master Entrepreneurship in Digital • Master Computer Science 2014 (adv	Fechnologies 2020 (advancec tional subject), advanced mo- module), Elective Computer S Fechnologies 2014 (advancec vanced module), advanced cu	d module), specific, Arbitra dule, Arbitrary semester Science, 1st or 2nd semeste module), specific, 2nd an urriculum, 2nd and/or 3rd	ry semester er d/or 3rd semester semester	
Classes and lectures: • Computer-Aided Design of Digital (	Circuits (s. CS3110 T) (lecture)	Workload: • 195 Hours private studies		
<ul> <li>with exercises, 3 SWS)</li> <li>Hardware/Software Co-Design (s. CS5170 T) (lecture with exercises, 3 SWS)</li> <li>Lab course System Architecture or Seminar System Architecture (practical course, 3 SWS)</li> </ul>		<ul> <li>135 Hours in-class</li> <li>30 Hours exam pr</li> </ul>	sroom work reparation	
Contents of teaching: • see module parts				
Qualification-goals/Competencies: • see module parts				
Grading through: • Oral examination				
Responsible for this module: • Prof. DrIng. Mladen Berekovic Teacher: • Institute of Computer Engineering				
Prof. DrIng. 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	
<ul> <li>Course of study, specific field and term:</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester</li> <li>Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester</li> <li>Master Media Informatics 2014 (optional subject), computer science, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd or 3rd semester</li> <li>Master Computer Science 2014 (advanced module), advanced curriculum, 2nd or 3rd semester</li> </ul>				
Classes and lectures:       Workload:         • CS4140 T: Mobile and distributed information systems (lecture with exercises, 3 SWS)       • 130 Hours private studies         • CS5140 T: Semantic Web (lecture with exercises, 3 SWS)       • 120 Hours in-classroom work         • Seminar data management (seminar, 2 SWS)       • 90 Hours work on an individual topic with written and ora presentation or group work         • 20 Hours exam preparation			e studies sroom work n an individual topic with written and oral yroup work reparation	
Contents of teaching: <ul> <li>see module parts</li> </ul> <li>Qualification-goals/Competencies: <ul> <li>see module parts</li> </ul> </li>				
Grading through: • Oral examination				
Responsible for this module: <ul> <li>Prof. Dr. Sven Groppe</li> </ul> Teacher: <ul> <li>Institute of Information Systems</li> <li>Prof. Dr. Sven Groppe</li> </ul>				
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, CS450	9 - Internet Structures an	d Protocols / Interne	t Technologies (Internet)
Duration:	Turnus of offer:		Credit points:
2 Semester	not available anymore		12
Course of study, specific field and ter Master Entrepreneurship in Digi Master Computer Science 2019 Master IT-Security 2019 (advance) Master Media Informatics 2014 ( Master Entrepreneurship in Digi Master Computer Science 2014	<b>m:</b> tal Technologies 2020 (advanced (optional subject), advanced mo ed module), Elective Computer S optional subject), computer scie tal Technologies 2014 (advanced (advanced module), advanced c	d module), specific, Arbitra dule, Arbitrary semester Science, 1st or 2nd semest ence, Arbitrary semester d module), specific, 2nd ar urriculum, 2nd and 3rd ser	ry semester er ıd 3rd semester nester
Classes and lectures:		Workload:	
<ul> <li>Architectures for Distributed Ap exercises, 3 SWS)</li> <li>Advanced Internet Technologies</li> <li>Software Architectures (project)</li> </ul>	pplications (lecture with es (lecture with exercises, 3 SWS) t work, 3 SWS) • 45 Hours group work • 45 Hours exam preparation		sroom work e studies n project vork reparation
Contents of teaching:			
<ul> <li>see module parts</li> </ul>			
Qualification-goals/Competencies: <ul> <li>see module parts</li> </ul>			
Grading through:			
Oral examination			
Responsible for this module: • Prof. Dr. Stefan Fischer			
Institute of Telematics			
<ul><li> Prof. DrIng Horst Hellbrück</li><li> Prof. DrIng. habil. Dennis Pfiste</li></ul>	rer		
Literature:			
• : see module parts			
Language: • German and English skills requir	ed		
Notes:			
(Consists of CS5158 T, CS4151 T).			
As of winter semester 2019/20, the	e module has been renamed from	m Internet Technologies to	o Internet Structures and Protocols.
As of winter semester 2020/21, the	e module is no longer offered to	new students.	
Admission requirements for taking - None	, the module:		
Admission requirements for taking - Successful participation in lab	y module examination(s):		



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 m Master MES 2020 (advanced module Master Entrepreneurship in Digital T Master Computer Science 2019 (opti Master Biophysics 2019 (advanced m Master IT-Security 2019 (advanced m Master MES 2014 (advanced module Master Entrepreneurship in Digital T Master Computer Science 2014 (advanced m	nodule), advanced curricului ), computer science / electri echnologies 2020 (advanced onal subject), advanced mo nodule), advanced curricului nodule), Elective Computer S ), computer science / electri echnologies 2014 (advanced anced module), advanced cu	m, 1st or 2nd semester ical engineering, Arbitrary d module), specific, Arbitra dule, Arbitrary semester m, 1st and 2nd semester Science, 1st or 2nd semest ical engineering, 1st and/c d module), specific, 2nd ar urriculum, 2nd and/or 3rd	semester ary semester er or 2nd semester nd/or 3rd semester semester
Classes and lectures:		Workload:	
<ul> <li>CS5260SJ14 T: Speech and Audio Signith exercises, 3 SWS)</li> <li>CS5275 T: Selected Topics of Signal A (lecture with exercises, 3 SWS)</li> <li>CS5194 T: Lab course (project work,</li> </ul>	<ul> <li>Classes and lectures: Workload:</li> <li>CS5260SJ14 T: Speech and Audio Signal Processing (lecture with exercises, 3 SWS)</li> <li>CS5275 T: Selected Topics of Signal Analysis and Enhancement (lecture with exercises, 3 SWS)</li> <li>CS5194 T: Lab course (project work 3 SWS)</li> <li>Workload:</li> <li>150 Hours privates (project work 3 SWS)</li> </ul>		e studies room work work reparation report
Contents of teaching:			
<ul> <li>Introduction to statistical signal analysis</li> <li>Principles of feature extraction and pattern recognition</li> <li>Linear optimum filters</li> <li>Adaptive filters</li> <li>Spectrum analysis</li> <li>Basic concepts of multirate signal processing</li> <li>Applications in speech and image processing</li> <li>Realization of signal processing tasks for typical application scenarios in teamwork</li> </ul>			
Qualification-goals/Competencies:			
<ul> <li>Students are able to explain the basis</li> <li>They are able to describe and apply</li> <li>Students are able to describe the co</li> <li>They are able to explain the concepts</li> <li>They are able to analyze and design</li> <li>Students are able to explain various</li> <li>They are able to create and implement</li> </ul>	c elements of stochastic sig linear estimation theory. ncepts of adaptive signal pr s of feature extraction and p multirate systems. practical applications of sig ent signal processing system	nal processing and optime ocessing. battern recognition. nal processing algorithms. ns on their own and in tear	um filtering. mwork.
Grading through: • Oral examination			
Responsible for this module:         • Prof. DrIng. Markus Kallinger         Teacher:         • Institute for Signal Processing         • Prof. DrIng. 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
<ul> <li>Course of study, specific field and term:</li> <li>Master Biophysics 2023 (advanced module), advanced curriculum, 1st or 2nd semester</li> <li>Master Computer Science 2019 (optional subject), Canonical Specialization Bioinformatics and Systems Biology, Arbitrary semester</li> <li>Master MES 2020 (advanced module), computer science / electrical engineering, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and AI, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Biophysics 2019 (advanced module), advanced curriculum, 1st and 2nd semester</li> <li>Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester</li> <li>Master MES 2014 (advanced module), computer science / electrical engineering, 1st and 2nd semester</li> <li>Master Entrepreneurship in Digital Technologies 2014 (advanced module), specific, 2nd and 3rd semester</li> </ul>			
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)		<ul> <li>Workload:</li> <li>180 Hours private studies</li> <li>120 Hours in-classroom work</li> <li>40 Hours exam preparation</li> <li>20 Hours work on an individual topic with written and oral presentation</li> </ul>	
Contents of teaching: • see module parts			
Qualification-goals/Competencies: <ul> <li>see module parts</li> </ul>			
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. DrIng. Erhardt Barth			
Literature: • : see module parts			
<ul> <li>Language:</li> <li>German and English skills required</li> </ul>			
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	
<ul> <li>Course of study, specific field and term:</li> <li>Master Robotics and Autonomous Systems 2019 (optional subject), Additionally recognized elective module, 1st to 3th semester</li> <li>Certificate in Artificial Intelligence (compulsory), Artificial Intelligence, 1st semester</li> <li>Master Entrepreneurship in Digital Technologies 2020 (advanced module), specific, Arbitrary semester</li> <li>Master Computer Science 2019 (optional subject), Canonical Specialization Data Science and Al, 1st or 2nd semester</li> <li>Master IT-Security 2019 (advanced module), Elective Computer Science, 1st or 2nd semester</li> <li>Master Computer Science 2019 (optional subject), advanced module, Arbitrary semester</li> </ul>				
Classes and lectures:Workload:• CS4514-P: Lab course Intelligent Agents (practical course, 2 SWS)• 195 Hours private studies • 120 Hours in-classroom work• CS4514-V: Intelligent Agents (lecture with exercises, 6 SWS)• 45 Hours exam preparation		e studies ssroom work reparation		
<ul> <li>Contents of teaching:</li> <li>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</li> <li>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 (OpenAl) / 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)</li> <li>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</li> <li>In the project lab students use the usual (open source) data science related programming languages and tools in order to transfer the</li> </ul>				
<ul> <li>Qualification-goals/Competencies:</li> <li>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.</li> </ul>				
Grading through: <ul> <li>Oral examination</li> </ul>				
<ul> <li>Responsible for this module: <ul> <li>Prof. DrIng. Nele Rußwinkel</li> </ul> </li> <li>Teacher: <ul> <li>Institute of Information Systems</li> <li>Prof. DrIng. Nele Rußwinkel</li> </ul> </li> <li>Literature: <ul> <li>J. Pearl, C. Glymour, and N.P. Jewell: Causal Inference in Statistics - A Primer - Wiley, 2016</li> <li>Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations - Cambridge University Press 2009</li> <li>S.J. Russell, P. Norvig: Artificial Intelligence: A Modern Approach - Pearson, 2020</li> <li>M. Ghallab, D. Nau, P. Traverso: Automated Planning and Acting - Cambridge University Press, 2016</li> </ul> </li> </ul>				
<ul> <li>• offered only in English</li> </ul>				



### 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 • Master IT-Security 2019 • Master Entrepreneurshi • Master Computer Scien	<b>I and term:</b> (optional subject), Elective Computer Sci p in Digital Technologies 2020 (optional ce 2019 (optional subject), advanced mo	ience, 1st or 2nd semester subject), specific, 2nd or 3 dule, Arbitrary semester	rd semester		
<ul> <li>Classes and lectures:</li> <li>Architectures for distributed communication systems (lecture, 2 SWS)</li> <li>Architectures for distributed communication systems (exercise, 1 SWS)</li> <li>Mobil communication systems (lecture, 2 SWS)</li> <li>Mobil communication systems (exercise, 1 SWS)</li> <li>Architectures for distributed communication systems (practical course, 3 SWS)</li> </ul>		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 Commu Wireless Data Link Layer Satellite Systems) Security in wireless Net Applications of wireless Software Architectures Basics of communication N-Tier Applications Architectures of distribution (Web 2.0), Overlay Network	<ul> <li>Contents of teaching:</li> <li>Introduction to Communication Systems and overview of the state-of-the-art technologies</li> <li>Wireless Data Link Layer, Network Layer and Technologies (802.15.4, WLAN, GSM, Bluetooth, RFID, LowPowerWANs, Broadcast and Satellite Systems)</li> <li>Security in wireless Networks</li> <li>Applications of wireless Networks</li> <li>Software Architectures</li> <li>Basics of communication in distributed networks</li> <li>N-Tier Applications</li> <li>Architectures of distributed systems (Service-Oriented and Event-Driven Architectures (SOA and EDA), Web-Oriented Architectures</li> </ul>				
Qualification-goals/Compete Students can highlight They interpret and follo They can systematically They can design, imple They can analyze techn They can carry out diag The students are able t other. For each architecture, t For a given problem, th realization.	ncies: the particularities of wireless mobile com ow current research activities and technol or design and evaluate protocols for mobil ment, and operate real-time applications ical requirements for mobile radio system proses, tests and optimizations of wireles on ame the most important archiectures hey know the most prominent and impo- ney can analyze which architecture is best	munication systems and t logy trends. le communication systems based on wireless communs and components and c s networked mobile comm for distributed systems, ex rtant implementation plat t suited to solve it, and the	the challenges and concepts. s and their applications. unication networks. hoose solutions. nunication systems. xplain them, and compare them to each forms and basically know how to use them. ey can design a plan for the solution's		
Grading through: • Oral examination					
Responsible for this module:					
Prof. Dr. Stefan Fischer					
Teacher:					
<ul> <li>Prof. DrIng Horst Hellbrück</li> <li>Dr. Mohamed Hail</li> </ul>					
Literature: • Jochen Schiller: Mobile	Communications - 2nd Edition, Addison-	Wesley, 2004, Signature: \	/K 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-KP1	2 - Current and Futu	re 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 (opt • Master IT-Security 2019 (optional su • Master Entrepreneurship in Digital T	ional subject), advanced m bject), Elective Computer S echnologies 2020 (optiona	odule, Arbitrary semester cience, 1st or 2nd semester l subject), specific, Arbitrary semester
Classes and lectures: Advanced Internet Technologies (le Advanced Internet Technologies (ex Nano communication networks (lec Nano communication networks (pro Seminar Internet of Things or Semir networks (seminar, 2 SWS)	cture, 2 SWS) tercise, 1 SWS) ture, 2 SWS) oject work, 1 SWS) ar Nano communication	<ul> <li>Workload:</li> <li>165 Hours private studies</li> <li>105 Hours in-classroom work</li> <li>45 Hours exam preparation</li> <li>30 Hours work on an individual topic with written and oral presentation</li> <li>15 Hours work on project</li> </ul>
<ul> <li>Contents of teaching:</li> <li>Fundamental Internet design princi</li> <li>Problems of today's Internet archite</li> <li>Backbone Technologies</li> <li>Mobile Internet</li> <li>IPv6 und related topics</li> <li>Delay Tolerant Networks (DTN)</li> <li>Internet of Services / Internet of Thi</li> <li>Peer-To-Peer networks</li> <li>Big Data</li> <li>Goals, architectures, algorithms, and</li> <li>Self-assembly systems</li> <li>Reductions and compilation</li> <li>Definitions &amp; associations of nanonetworks</li> <li>Dimulation tools for nanonetworks</li> <li>Deployment in medical application</li> </ul>	ples cture ngs I protocols for the future In etworks scenarios	ternet
<ul> <li>Qualification-goals/Competencies:</li> <li>Understand the fundamental design</li> <li>Understand the original design goan networks</li> <li>Learn about essential, universally valetc.)</li> <li>Know technological as well as societ innovations, mobile communication</li> <li>Identify problems of the Internet's at Become acquainted with the Future future</li> <li>They can design, implement and test</li> <li>They can deal with real-world use cat they recognize the current trends at Students know and understand the</li> <li>Students know and understand the</li> <li>Students know and understand the</li> <li>Students know how to verify or falsi</li> <li>Students can transfer basic theoretic</li> </ul>	n decisions that have led to ls of the Internet and realize lid criteria for the design of tal developments that have is, ) rchitecture and understance Internet research field and st basic IoT applications. and interpret data from IoT ases and be able to develop nd future developments in basic concepts of nanonet f nanoscale computational -assembly systems and crys constraints and peculiaritie fy a model using simulatio cal concepts to related que	today's Internet architecture e the implications that the emphasis on certain of them has on today's f networks and applications (e.g., end-to-end argument, fate sharing, e led to massive changes in the Internet's infrastructure (growth, d potential solutions by comparing different approaches l learn about novel approaches to research and shape the Internet of the systems. o solutions for specific industries. the IoT area and can evaluate them critically. works. models. stal formation. es at the nanoscale. n tools. stions.
Grading through: • Oral examination		



Responsible for this module: <ul> <li>Prof. Dr. Stefan Fischer</li> </ul> Teacher: <ul> <li>Institute of Telematics</li> </ul>
<ul> <li>Dr. Mohamed Hail</li> <li>Dr. rer. nat. Florian-Lennert Lau</li> </ul>
Literature: <ul> <li>Olivier Hersent, David Boswarthick, Omar Elloumi: The Internet of Things: Key Applications and Protocols - Wiley, 2012</li> </ul>
<ul><li>Language:</li><li>English, except in case of only German-speaking participants</li></ul>
Notes: Admission requirements for taking the module: - None Admission requirements for participation in module examination(c):
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.





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СS4210-КР	06, CS4210 - Crypto	graphic Protocols (K	rypProto)
Duration: T	urnus of offer:		Credit points:
1 Semester n	ormally each year in the s	summer semester	6
Course of study, specific field and term: Master Media Informatics 2020 (optional Master Medical Informatics 2019 (optional Master IT-Security 2019 (optional subjection) Master Medical Informatics 2014 (option)	al subject), computer scie nal subject), ehealth / info ct), IT Security and Privacy nal subject), ehealth / info	nce, Arbitrary semester omatics, 1st or 2nd semest y, 1st, 2nd, or 3rd semester omatics, 1st or 2nd semest	ter r ter
Classes and lectures:		Workload:	
<ul> <li>Cryptographic Protocols (lecture, 3 SWS</li> <li>Cryptographic Protocols (exercise, 1,5 S</li> </ul>	S) SWS)	<ul> <li>85 Hours private :</li> <li>75 Hours in-class</li> <li>20 Hours exam private :</li> </ul>	studies and exercises room work reparation
Contents of teaching: • Complex cryptographic protocols, secu • Anonymity and Privacy, Private Compu • Quantum Cryptographie • Steganography, digital seals and water • secure e-commerce, electronic money, Qualification-goals/Competencies:	irity analyses itation and Information Re marks online elections	etrieval, Differential Privacy	y
<ul> <li>The students can reason about cryptog</li> <li>The are able to select suitable security</li> <li>The can conduct a security analysis of c</li> <li>They can designate the weaknesses of</li> </ul>	praphic methods and their primitives for given applic communication protocols real systems and evaluate	r application in communic cations and to implement e them.	ation systems. them.
Grading through:     Oral examination			
Requires: • Cryptology (CS3420-KP04, CS3420)			
Responsible for this module: • Prof. Dr. Rüdiger Reischuk Teacher: • Institute for Theoretical Computer Scier • Prof. Dr. Maciej Liskiewicz • Prof. Dr. Rüdiger Reischuk	nce		
Literature: Lindell: Tutorials on the Foundations of J. Katz, Y. Lindell: Introduction to Mode Goldreich: Fundamentals of Cryptograp I. Cox, M. Miller, J. Bloom, J. Fridrich, T. I Dwork, Roth: The Algorithmic Foundati	f Cryptography - Springer rrn Cryptography - CRC Pr ohy - Cambridge Univ. Pre Kalkerm: Digital Waterma ions of Differential Privacy	2017 ess 2014 ess 2004 rking and Steganography / - 2014	- Morgan Kaufmann 2008
Language: • English, except in case of only German-	speaking participants		
Notes: Admission requirements for taking the m - None (the competencies under	odule:		



CS42	11-KP06, CS4211 - Modeling a	nd Analysing Securit	y (SecurAna_a)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		6
Course of study, specific field a	and term:		
<ul> <li>Master IT-Security 2019 (</li> <li>Master Medical Informati</li> </ul>	optional subject), IT Security and Priva cs 2014 (optional subject), major subje	cy, 1st, 2nd, or 3rd semeste ct informatics, 1st or 2nd s	emester
Classes and lectures:		Workload:	
<ul><li>Modeling and Analysing</li><li>Modeling and Analysing</li><li>Modeling and Analysing</li></ul>	Security (lecture, 3 SWS) Security (exercise, 1 SWS) Security (practical course, 1 SWS)	<ul><li>85 Hours private</li><li>75 Hours in-class</li><li>20 Hours exam p</li></ul>	studies and exercises room work reparation
Contents of teaching:			
<ul> <li>Modelling and formalizin</li> <li>Adversaries and models</li> <li>Symbolic methods and a</li> <li>Consistency and synchromic</li> </ul>	ng protocols and security properties of attacks, security pitfalls utomatic verification of security prope nization	rties	
Qualification-goals/Competen	cies:		
<ul> <li>The students can compre-</li> <li>They can report on securing the securing the securing the security of the security</li></ul>	ehensively elaborate on algorithmic ba ity properties. methods for IT security and apply ther analyse and verify protocols and secur ques for automatic verification of secu	sics for IT security. n. ity properties. rity properties.	
Grading through: • Oral examination			
Requires:			
Cryptology (CS3420-KP04	4, CS3420)		
Responsible for this module:			
Prof. Dr. Rüdiger Reischu	k		
Teacher:     Institute for Theoretical C	Computer Science		
Prof. Dr. Maciej Liskiewic:	Z		
Prof. Dr. Rüdiger Reischu	k		
Literature:			
<ul> <li>V. Cortier, S. Kremer, edit Series 5, IOS Press, 2011</li> <li>C. P. Pfleeger, S. L. Pfleege</li> <li>A. Joux: Algorithmic Cryp</li> <li>J. Katz, Y. Lindell: Introdu</li> <li>S. Loepp, W. Wootters: Provide the second second</li></ul>	ors: Formal Models and Techniques for er: Security in Computing - Prentice-Ha otanalysis - CRC Press 2009 ction to Modern Cryptography - Chapr rotecting Information - Cambridge Univ	· Analyzing Security Protoc all, 2007 nan & Hall 2008 v. Press 2006	ols - Cryptology and Information Security
Language:			
English, except in case of	only German-speaking participants		
Notes: Admission requirements fo - None (the competencies o	r taking the module: 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 a • Master Entrepreneurship • Master IT-Security 2019 (	and term: in Digital Technologies 2020 (advanc optional subject). IT Security and Priva	ed module), specific, Arbitrary semester acv. 1st. 2nd. or 3rd semester
Classes and lectures: • Networks and Mobile Sy: • Networks and Mobile Sy:	stems (lecture, 2 SWS) stems (exercise, 2 SWS)	Workload: • 90 Hours private studies • 60 Hours in-classroom work • 30 Hours exam preparation
Contents of teaching:		
<ul> <li>Introduction into the spe</li> <li>Security Architectures fo</li> <li>Security in Wireless Loca</li> <li>Security in the Internet of</li> <li>Security for embedded of</li> </ul>	ecial security problems of mobile syste r wireless wide area netwirks (GSM, Ul l Area Networks (WLAN, Bluetooth) f Things (basics, key management, int levices	ms ATS, LTE) egrity, authenticity, RFID)
<ul> <li>Qualification-goals/Competen</li> <li>The successful participar systems.</li> <li>They are able to correctly</li> <li>They are able to assess n</li> </ul>	<b>cies:</b> Its understand the central concepts, n y apply existing solutions, develop ow ew security problems and solutions co	iethods, and mechanisms to secure wireless networks and mobile n new solutions and assess their validity. oming from research.
Grading through: • Written or oral exam as a	nnounced by the examiner	
Responsible for this module: <ul> <li>Prof. Dr. Stefan Fischer</li> </ul> Teacher: <ul> <li>Institute of Telematics</li> <li>Prof. Dr. Stefan Fischer</li> </ul>		
Literature:		
Claudia Eckert: IT-Sicherh	neit - Oldenbourg, 8th ed., 2013	
Language: • German and English skill	s required	
Notes: Admission requirements fo - None Admission requirements fo - none	r taking the module: r participation in module examinatior	ı(s):
Module Exam(s): - CS4450-L1: Networks and	Mobile Systems, oral examination, 10	0% 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 (opti • Master Medical Informatics 2014 (op • Master Medical Informatics 2019 (op • Master IT-Security 2019 (optional sub	onal subject), Elective, Arbi tional subject), ehealth / in tional subject), ehealth / in oject), IT Security and Priva	itrary semester fomatics, 1st or 2nd semest fomatics, 1st or 2nd semest cy, 1st, 2nd, or 3rd semeste	ter ter r
Classes and lectures: • Privacy (lecture, 2 SWS) • Privacy (exercise, 2 SWS)		Workload: • 100 Hours private • 60 Hours in-class • 20 Hours exam p	e studies room work reparation
Contents of teaching: Private statistics (Differential Privacy) Privacy preserving machine learning Privacy attacks against machine-lear Privacy-preserving computation in d Stylometry: de-anonymization via wr Anonymity	) ned models istributed systems. riting style		
Qualification-goals/Competencies: <ul> <li>Deep understanding for algorithmic</li> <li>Skills to analyze complex security red</li> </ul>	and algebraic methods to quirements	secure private data	
Grading through: • Oral examination			
Requires: • Trustworthy Al (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 F- • Stanford: Encyclopedia of Philosophy • Andrej Bogdanov: Lecture notes by A- • Journal und Konferenz-Publikationer	oundations of Differential I y on Privacy Andrej Bogdanov from Chin n: wird aktuell benannt	Privacy - Now Publishers Ind	c, 2014 ng
Language: • English, except in case of only Germa	an-speaking participants		
Notes: Admission requirements for taking the - None (the competencies under	module:		



	CS4702-KP06 - Comput	er Security (CoSec)	
Duration:	Turnus of offer:	c	Fredit points:
1 Semester	normally each year in the sur	nmer semester 6	5
Course of study, specific field and term: • Master Robotics and Autonomous S • Master Entrepreneurship in Digital T • Master Media Informatics 2020 (opt • Master Medical Informatics 2019 (op • Master IT-Security 2019 (optional su	ystems 2019 (optional subject) Technologies 2020 (advanced n ional subject), computer scienc ptional subject), ehealth / inforr bject), IT Security and Privacy,	, Additionally recognized e nodule), specific, Arbitrary e, Arbitrary semester natics, 1st or 2nd semester Ist, 2nd, or 3rd semester	elective module, Arbitrary semester semester ,
Classes and lectures:		Workload:	
<ul> <li>Computer Security (lecture, 2 SWS)</li> <li>Computer Security (practical course</li> </ul>	, 3 SWS)	<ul> <li>85 Hours private stu</li> <li>75 Hours in-classroot</li> <li>20 Hours exam prepared</li> </ul>	udies om work paration
Contents of teaching:			
<ul> <li>Applied cryptography in systems and Efficient and secure implementation time algorithms etc.</li> <li>Physical implementation attacks and attacks, modern inference methods</li> <li>Virtualization security and microarch attacks such as cache attacks, spect</li> <li>Trusted computing and hardware-a basics and cryptographic technique</li> </ul>	d countermeasures: Error inject and associated cryptanalysis m hitecture attacks: security conce re, etc., measures to restore syst ssisted system security: How TF s, design basics for secure syste	ion attacks, passive physic nethods, classes of protect epts in the operating syste tem security PMs, Secure Elements and ems	metic, efficient exponentiation, constant cal attacks such as SPA/DPA and timing tive measures em and hypervisor, microarchitecture Trusted Execution work environments,
<ul> <li>The students can demonstrate a detempoint of the students can construct secure and efficition.</li> <li>They can explain methods and algo</li> <li>They can perform basic side-channe</li> <li>They can implement protection aga</li> <li>They can evaluate the security of explanation.</li> </ul>	ep understanding of cryptogra ient cryptographic primitives a rithms for efficient multiple-pra el attacks on systems with phys inst specific physical attacks fo isting primitives.	phic methods and their ap nd implement them secure ecision arithmetic. ical access or shared syste r cryptographic primitives	oplications in communication systems. ely in computer systems. ems with code execution rights. 
Grading through: • Viva Voce or test • written homework			
Requires: • Cybersecurity (CS2250-KP04)			
Responsible for this module: <ul> <li>Prof. DrIng. Thomas Eisenbarth</li> </ul> Teacher: <ul> <li>Institute for IT Security</li> <li>Prof. DrIng. Thomas Eisenbarth</li> </ul>			
<ul> <li>Literature:</li> <li>S. Mangard, E. Oswald &amp; T. Popp: Po Media, 2008</li> <li>D. Stinson: Cryptography: Theory ar</li> <li>: Recent literature</li> </ul>	wer analysis attacks: Revealing nd Practice - 4th ed., CRC Press,	the secrets of smart cards	s - Vol. 31, Springer Science & Business
Language: • English, except in case of only Germ	an-speaking participants		



### Notes:

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



CS4	703-KP06 - Advanced	l Cryptology (AdvCry	pto)
Duration:	Turnus of offer:		Credit points:
1 Semester	every summer semester		6
Course of study, specific field and term: • Master Computer Science 2019 (option • Master Robotics and Autonomous Sy • Master CLS 2016 (optional subject), of • Master IT-Security 2019 (optional subject)	onal subject), Elective, Arbit stems 2019 (optional subje omputer science, 3rd seme oject), IT Security and Privac	trary semester ect), Additionally recognize ester cy, Arbitrary semester	d elective module, Arbitrary semester
<ul> <li>Classes and lectures:</li> <li>Lecture Advanced Cryptoplogy (lecture)</li> <li>Exercise Advanced Cryptoplogy (seme exercises, 1 SWS)</li> </ul>	ıre, 3 SWS) iinar-style lectures with	Workload: • 100 Hours private • 60 Hours in-class • 20 Hours exam p	e studies room work reparation
<ul> <li>Contents of teaching:</li> <li>Concrete security and asymptotic see</li> <li>Block-Ciphers: Feistel Networks, Subsee</li> <li>Authenticated Encryption</li> <li>Secure multi-party calculations: prepresent evidence)</li> <li>Obfuscation: Nicht-Machbarkeit (Black</li> </ul>	curity: comparison of both stitution-Permutation Netw rocessing model, protectio ckBox), Machbarkeit (indisti	approaches in relation to n rorks, Design Principles, Lin n of algorithms against sid nguishable Obfuscation)	nodes of operations lear Cryptanalysis, Differential cryptanalysis e-channel attacks, MPC-in-the-Head (for ZK
Qualification-goals/Competencies: <ul> <li>The participants can explain and use</li> <li>They are able to understand current</li> <li>They show a deep understanding of</li> <li>They understand the basic connection</li> <li>They are able to understand current</li> </ul>	basic theoretic cryptograp concepts of cryptography cryptographic methods on between theoretical and scientific works about cryp	hic objects practical aspects of crypto tography and explain them	יgraphy ז
Grading through: • Written or oral exam as announced b • written homework	y the examiner		
Requires: • Cryptology (CS3420-KP04, CS3420)			
Responsible for this module: • Prof. DrIng. Thomas Eisenbarth Teacher: • Institute for IT Security • Dr Sebastian Berndt			
Literature: • Katz, Lindell: Introduction to Modern • Cramer, Damgård, Nielsen: Secure M • Barak: An Intensive Introduction to C	Cryptography - 2nd ed., Cl ultiparty Computation and ryptography - Lecture Note	RC Press, 2014 Secret Sharing - 1st ed., Ca es	ambridge University Press, 2015
Language: • English, except in case of only Germa	n-speaking participants		
Notes: Admission requirements for taking the - None (the competencies under	module:		



Ĺ	S4705-KP06 - Cryptograpł	ic Engineering (CryEng)	
Duration:	Turnus of offer:	Credit p	points:
1 Semester	every summer semester	6	
Course of study, specific field and terr • Master Entrepreneurship in Digit • Master Robotics and Autonomou • Master Computer Science 2019 ( • Master IT-Security 2019 (optiona	n: al Technologies 2020 (advanced r is Systems 2019 (optional subject optional subject), Elective, Arbitra subject), IT Security and Privacy,	nodule), specific, Arbitrary semest , Additionally recognized elective ry semester 1st, 2nd, or 3rd semester	ter e module, Arbitrary semester
Classes and lectures:		Workload:	
<ul> <li>Cryptographic Engineering (lect)</li> <li>Cryptographic Engineering (exer)</li> </ul>	ıre, 2 SWS) cise, 2 SWS)	<ul> <li>100 Hours private studies</li> <li>60 Hours in-classroom wor</li> <li>20 Hours exam preparation</li> </ul>	rk n
Contents of teaching: • Efficient Implementation of Finit • Stream Ciphers: Design and hard • Block Ciphers: Design, hardware • Hash Functions: Design and hard • Public-Key Cryptography over G • True and Pseudo Random Numb • Physical Unclonable Functions (F	e Field Arithmetic for cryptograph ware Implementation. Implementation, and Lightweigh ware Implementation. <sup>E</sup> (2m): Design and Implementatio er Generators (TRNG): Design, tes PUFs): Design Challenges and Hard	ic Applications. Encryption Algorithms. n. t, and hardware Implementation. Iware- Architectures.	
Qualification-goals/Competencies: • Students will become familiar w • They can expand and enhance to • They can become more familiar • They can learn efficient impleme • They can learn the techniques for • They can demonstrate a deep un • They can take an advanced step	th the concept of cryptographic entry the concept of cryptographic entry the concepts of hardware-se ntation of Finite Field Arithmetic r hardware-implementation of cryptographic structures towards hardware and physical second structures structures and physical second structures and physical second structures structures and physical second structures and physical second structures structures structures and structures structures structures structures and second structures struct	ngineering and the associated to phy and applied cryptography. curity. n hardware and its applications in ptographic algorithms and designs of stream and block ecurity such as TRNG, PUFs.	pics with it. n cryptography. ciphers
Grading through: • written exam			
Requires: • Cryptology (CS3420-KP04, CS342	0)		
Responsible for this module: • Prof. DrIng. Mladen Berekovic Teacher: • Institute of Computer Engineerin • DrIng. Saleh Mulhem	g		
Literature: • Ferguson, Niels, Bruce Schneier, • Koç Ç.K.: Cryptographic Enginee • Wachsmann, Christian, and Ahm Morgan & Claypool Publishers, 2 • Johnston, David: Random Numb GmbH & Co KG, 2018 Language: • offered only in English	and Tadayoshi Kohno: Cryptograp ing - Springer, Boston, MA, (2009 ad-Reza Sadeghi: Physically unclo 014 er Generators Principles and Prac	hy Engineering: Design Principles nable functions (PUFs): Applicatic tices: A Guide for Engineers and F	s and Practical Applications - 2012 ons, models, and future directions - Programmers - Walter de Gruyter



### 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.





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	CS5075-KP06 - Trus	stworthy 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 (opti • Master Medical Informatics 2019 (op • Master IT-Security 2019 (optional sul	ional subject), Elective, Arbi itional subject), ehealth / in bject), IT Security and Priva	itrary semester fomatics, 1st or 2nd semes cy, 1st, 2nd, or 3rd semeste	ter r
Classes and lectures: CS5075-V: Trustworthy AI (lecture, 3 CS5075-Ü: Trustworthy AI (exercise,	SWS) 1 SWS)	Workload: • 100 Hours private • 60 Hours in-class • 20 Hours exam p	e studies room work reparation
Contents of teaching: Guiding principles of Trustworthy All Trustworthy Computing Basics: Secu De-anonymization methods using m Mathematical notions for privacy-pr Privacy-preserving machine learning Analyse maschinell gelernter Modell Verifikation maschinell gelernter Modell Verifikation maschinell gelernter Modell Attacks for manipulating machine learning met Hardening of machine learning method (Privacy-Preserving Federated Learn	: lawful, ethical and robust irity, Privacy, Dependability nachine learning models eserving machine learning methods len (Robustness Check, Exp idellen ((Statistical Testing), achine learning models (for earning models (adversarial hods against manipulation atta ing)	AI , Safety, Transparency, Exp methods lainability) Model Checking) r economical reasons, for ar examples, backdoors) methods icksSecure and privacy-pres	lainability, Traceability, Accountability nalysis, and for verification) serving distributed learning methods
<ul> <li>Qualification-goals/Competencies:</li> <li>All current techniques taught in the proofs can be explained on the basi.</li> <li>The formal foundations from the could be students are able to identify advant</li> <li>Understanding about potential vuln</li> <li>Understanding of hardening method</li> <li>Students can analyze complex security</li> </ul>	module and described abo s of applications. urse can be precisely explai ages and disadvantages of erabilities of machine learn ds compared to deanonym 'ity requirements	ive can be named and defin ned planning and acting appro ing methods w.r.t. privacy- ization and manipulation n	ned by the students and their functional aches violations and manipulation possibilities nethods
Grading through: • Oral examination			
Is requisite for: • Privacy (CS4451-KP06)			
Responsible for this module: • Prof. Dr. Esfandiar Mohammadi Teacher: • Institute of Software Technology and • Institute for IT Security • Prof. DrIng. Thomas Eisenbarth • Prof. Dr. Martin Leucker • Prof. Dr. Esfandiar Mohammadi	ታ Programming Languages		
Literature: • C. Dwork, A. Roth: The Algorithmic F • Andrej Bogdanov: Lecture notes by	oundations of Differential f Andrej Bogdanov from Chi	Privacy - Now Publishers In nese University of Hong Ko	c, 2014 ng

• : 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

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#### 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 - N	Model Checking (Mod	lelChe14)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		6
Course of study, specific field and term: • Master MES 2020 (optional subject), • Master IT-Security 2019 (optional subject), • Master MES 2014 (optional subject), • Master Medical Informatics 2014 (optional subject) • Master Computer Science 2014 (optional subject)	computer science / electric oject), IT Safety and Reliabil computer science / electric tional subject), computer s onal subject), specializatior	al engineering, Arbitrary se lity, 1st, 2nd, or 3rd semest al engineering, Arbitrary se cience, 1st or 2nd semeste n field IT security and safety	emester er emester r y, 1st or 2nd semester
Classes and lectures:		Workload:	
<ul> <li>Model Checking (lecture, 3 SWS)</li> <li>Model Checking (exercise, 1 SWS)</li> </ul>		<ul> <li>100 Hours private</li> <li>60 Hours in-class</li> <li>20 Hours exam p</li> </ul>	e studies and exercises room work reparation
Contents of teaching:			
<ul> <li>Quality aspects of software systems</li> <li>Analysis and verification techniques</li> <li>Basic techniques for model checking</li> <li>Advanced techniques for model checking</li> </ul>	for software systems I cking		
<ul> <li>The students can describe and comp</li> <li>They can construct, analyse and eva</li> <li>They can characterize different syste</li> <li>They can illustrate different techniques.</li> <li>They can explain the structure of mode</li> <li>They can evaluate the possibilities and</li> </ul>	bare analysis and verificatio luate specifications of corre m models and can formally ues for model checking har odel checkers and can use r nd limitations of model che	n techniques. ectness and safety propertion y represent sysstems in suit dware and software system model checkers. ecking.	es. table models. ns and can select and apply suitable
Grading through: • Written or oral exam as announced b	by the examiner		
Responsible for this module: • Prof. Dr. Martin Leucker Teacher: • Institute of Software Technology and • Prof. Dr. Martin Leucker	l Programming Languages		
Literature: • C. Baier, JP. Katoen: Principles of M	odel Checking - MIT Press, 2	2008	
Language: • English, except in case of only Germa	an-speaking participants		
Notes: Prerequisites for attending the module - None Prerequisites for the exam: - Successful completion of homework a	e: assignments during the ser	nester	



Credit points: 6 al engineering, Arbitrary semester ence, Arbitrary semester ity, 1st, 2nd, or 3rd semester al engineering, Arbitrary semester cience, 1st or 2nd semester ence, Arbitrary semester n field IT security and safety, 1st or 2nd semester <b>Workload:</b> • 100 Hours private studies and exercises • 60 Hours in-classroom work • 20 Hours exam preparation
6 al engineering, Arbitrary semester ence, Arbitrary semester ity, 1st, 2nd, or 3rd semester al engineering, Arbitrary semester cience, 1st or 2nd semester ence, Arbitrary semester in field IT security and safety, 1st or 2nd semester <b>Workload:</b> • 100 Hours private studies and exercises • 60 Hours in-classroom work • 20 Hours exam preparation
al engineering, Arbitrary semester ence, Arbitrary semester ity, 1st, 2nd, or 3rd semester al engineering, Arbitrary semester cience, 1st or 2nd semester ence, Arbitrary semester in field IT security and safety, 1st or 2nd semester <b>Workload:</b> • 100 Hours private studies and exercises • 60 Hours in-classroom work • 20 Hours exam preparation
<ul> <li>Workload:</li> <li>100 Hours private studies and exercises</li> <li>60 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>
<ul> <li>100 Hours private studies and exercises</li> <li>60 Hours in-classroom work</li> <li>20 Hours exam preparation</li> </ul>
n techniques. ectness and safety properties. d software systems and can select and apply suitable techniques. tools and can clasify suitable applications. onitors. her quality.
l, 1999 Iel-Based Testing of Reactive Systems - Springer, 2005 and TLTL - ACM TOSEM, 2011 2008



# 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 S • Master Computer Science 2019 (opt • Master IT-Security 2019 (optional su	ystems 2019 (optional subje ional subject), Elective, Arbi bject), IT Safety and Reliabil	ect), Additionally recognized trary semester ity, 1st, 2nd, or 3rd semester	d elective module, Arbitrary semester er	
Classes and lectures: • Reliability Engineering (lecture, 2 SV • Reliability Engineering (exercise, 2 S	VS) WS)	Workload: • 100 Hours private • 60 Hours in-classi • 20 Hours exam pl	e studies room work reparation	
Contents of teaching: • Basic concepts • Reliability analysis • Qualification tests • Maintainability analysis • Design guidelines for reliability, mai	intainability and software qu	ıality		
Qualification-goals/Competencies: • Students are able to discuss the bas • They are able to analyze the reliabili • They are able to select and apply qu • They are able to perform a maintain • They are able to follow design guide	ic concepts of Reliabilty Eng ity of technical systems by n ualification tests nability analysis elines for reliable and maint	ineering nathematical models ainable systems.		
Grading through: • Viva Voce or test				
Responsible for this module: • Prof. DrIng. Mladen Berekovic Teacher: • Institute of Computer Engineering • DrIng. Saleh Mulhem				
Literature: • A. Birolini: Reliability Engineering: TI • M. Rausand: Reliability of Safety-Crit	heory and Practice - Springe tical Systems - Wiley 2014	r 2013		
Language: • English, except in case of only Germ	an-speaking participants			
Notes: Admission requirements for taking the - None Admission requirements for participat - Successful completion of exercises as Module Exam(s):	e module: ion in module examination( s specified at the beginning	s): of the semester.		
- CS4452-L1: Technical Reliability, write According to the decision of the exam	ten exam, 90min, 100% of th ination board of computer	ne module grade. science of 15.1.2020 this m	odule can be chosen by students Master	

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.





uration: Turnus of	offer:		
		Credit points:	
Semester normally e	ach year in the winter semester	6	
Course of study, specific field and term:			
Master IT-Security 2019 (optional subject), IT Safe	ety and Reliability, 1st, 2nd, or 3rd se	mester	
Classes and lectures:	Workload:		
• Static Analysis (lecture, 3 SWS)	• 100 Hours p	private studies	
Static Analysis (exercise, 1 SWS)	<ul><li>60 Hours in-classroom work</li><li>20 Hours exam preparation</li></ul>		
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 and immediate			
<ul> <li>The students can illustrate the capabilities of star</li> <li>They can explain and classify the techniques for</li> <li>They can select appropriate analysis methods, ar</li> <li>They can relate, compare and evaluate various sr</li> <li>They can describe approaches for bytecode analysis</li> </ul>	tic analysis. automatic static source code analysi nd employ and combine them. tatic methods in order to increase so veis	s. ftware quality.	
<ul> <li>They can describe approaches for bytecode analytic of the second approaches for bytecode approaches fo</li></ul>	ic analysis.		
They can organize and execute manual code ins	pections.		
Grading through:			
• written exam, oral exam and/or presentation as a	announced by the examiner		
Responsible for this module:			
Prof. Dr. Martin Leucker			
Teacher:			
Institute of Software Technology and Programm	ing Languages		
Prof. Dr. Martin Leucker			
Literature:			
<ul> <li>F. Nielson, H.R. Nielson, C. Hankin: Principles of P</li> <li>H. Seidl, R. Wilhelm, S. Hack: Übersetzerbau Banc</li> </ul>	rogram Analysis - Springer, 2010 I 3: Analyse und Transformation - Sp	ringer 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.