M.Sc. Electrical Engineering and Information Technology (PO 2014)

Computer Engineering
Date: 01.09.2021

TECHNISCHE UNIVERSITÄT DARMSTADT

Department of Electrical Engineering and Information Technology

Module manual: M.Sc. Electrical Engineering and Information Technology (PO 2014)
Computer Engineering
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Department of Electrical Engineering and Information Technology
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Contents

1 Fundamentals

Module name Advanced Digital Integrated Circuit Design					
Module Nr. 18-ho-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** MOS Transistor Models, CMOS Logic Gates, Chip Layout and Design Rules, Static and Dynamic Behavior of CMOS Circuits, Synchonous CMOS Circuits, Performance and Power Characterisation, Design Techniques and CAD Tools, FPGA and Gate Array Technologies, Memory Technologies, Chip Test.
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • understand the short-channel effects of modern CMOS transistors, • derive and analyse the most important circuit concepts for digital logic gates, • understand the design flow of digital ASICs based on standard cells (design, layout, simulation/verification), • knows the pros and cons of synchronous vs. asynchronous logic, multiclockphase systems, • understands the differential design methods of integrated circuits (ASIC, ASIP, Full-custom/Semicustom, PLA, PLD, FPGA), • understands basic circuitry of logic and arithmetic units (adders, multipliers, PLL/DLL), • knows the design principles and properties of integrated semiconductor memory (DRAM, SRAM, Flash. MRAM, FeRAM)
3	**Recommended prerequisite for participation** Lecture “Electronics”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design
Courses	

	Course Nr. 18-ho-2010-vl	**Course name** Advanced Digital Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 3
	Course Nr. 18-ho-2010-ue	**Course name** Advanced Digital Integrated Circuit Design		
	Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1

Module name Communication Networks II					
Module Nr. 18-sm-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** WiSe
Language English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

Topics are:

- Basics and History of Communication Networks (Telegraphy vs. Telephony, Reference Models, ...)
- Transport Layer (Addressing, Flow Control, Connection Management, Error Detection, Congestion Control, ...)
- Transport Protocols (TCP, SCTP)
- Interactive Protocols (Telnet, SSH, FTP, ...)
- Electronic Mail (SMTP, POP3, IMAP, MIME, ...)
- World Wide Web (HTML, URL, HTTP, DNS, ...)
- Distributed Programming (RPC, Web Services, Event-based Communication)
- SOA (WSDL, SOAP, REST, UDDI, ...)
- Cloud Computing (SaaS, PaaS, IaaS, Virtualization, ...)
- Overlay Networks (Unstructured P2P, DHT Systems, Application Layer Multicast, ...)
- Video Streaming (HTTP Streaming, Flash Streaming, RTP/RTSP, P2P Streaming, ...)
- VoIP and Instant Messaging (SIP, H.323)

2 Learning objectives / Learning Outcomes

The course Communication Networks II covers the principles and practice of computer networking and telecommunications with emphasis on the Internet. Starting with the history, the course discusses past, current and future aspects of communication networks. In addition to the basics including well known protocols and technologies, recent developments in the area of multimedia communication (e.g., Video Streaming, P2P, IP-Telephony, Cloud Computing and Service-oriented Architectures) will be examined thoroughly. The course is designed as follow-up to Communication Networks I.

3 Recommended prerequisite for participation

Basic courses of first 4 semesters are required. Knowledge in the topics covered by the course Communication Networks I is recommended. Theoretical knowledge obtained in the course Communication Networks II will be strengthened in practical programming exercises. So, basic programming skills are beneficial.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Duration: 120 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Written Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, Wi-ETiT, CS, Wi-CS

7 Grade bonus compliant to §25 (2)

8 References

Selected chapters from following books:

- Andrew S. Tanenbaum: Computer Networks, Fourth 5th Edition, Prentice Hall, 2010
- James F. Kurose, Keith Ross: Computer Networking: A Top-Down Approach, 6th Edition, Addison-Wesley, 2009
- Larry Peterson, Bruce Davie: Computer Networks, 5th Edition, Elsevier Science, 2011

Courses

Course Nr.	**Course name**		
18-sm-2010-vl	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Lecture	3

Course Nr.	**Course name**		
18-sm-2010-ue	Communication Networks II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Philipp Achenbach, M.Sc. Tobias Meuser, M.Sc. Christoph Gärtner		Practice	1

Module name Computer Systems II					
Module Nr. 18-hb-2030	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** • Configurable Technologies • FPGA architectures and properties • System-On-Chip, HW components, SW toolchain, support SW • Coarse grained reconfigurable architectures, PE architecture, Modulo schedu-ling
2	**Learning objectives / Learning Outcomes** After completion of the module, students know reconfigurable technologies as well as chip architecture that employ them (e.g. FPGAs and CGRAs). They can select an ap-propriate technology for a given specific application. They know the components a system-on-chip (SoC) consists of. Students can configure and program an application specific SoC. They can map simple applications to a CGRA and know the limitations and pitfalls of this mapping.
3	**Recommended prerequisite for participation** Thorough basic knowledge of digital circuits and computer achitecture. as can be ob-tained in the lectures “Logischer Entwurf” and “Rechnersysteme I”. Additionally, stu-dents should be able to write simple programs in the programming language C.
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc iCE, MSc Wi-ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** The slides (in German) of the lecture can be obtained through moodle.

Courses

Course Nr.	**Course name**		
18-hb-2030-vl	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, M.Sc. Ramon Wirsch		Lecture	3
Course Nr.	**Course name**		
18-hb-2030-ue	Computer Systems II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger, M.Sc. Ramon Wirsch		Practice	1

Module name Software-Engineering - Maintenance and Quality Assurance					
Module Nr. 18-su-2010	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture covers advanced topics in the software engineering field that deal with maintenance and quality assurance of software. Therefore, those areas of the software engineering body of knowledge which are not addressed by the preceding introductory lecture, are in focus. The main topics of interest are: software maintenance and reengineering, configuration management, static programme analysis and metrics, dynamic programme analysis and runtime testing as well as programme transformations (refactoring). During the exercises, a suitable Java open source project has been chosen as running example. The participants analyze, test and restructure the software in teams, each dealing with different subsystems.
2	**Learning objectives / Learning Outcomes** The lecture uses a single running example to teach basic software maintenance and quality assuring techniques in a practice-oriented style. After attendance of the lecture a student should be familiar with all activities needed to maintain and evolve a software system of considerable size. Main emphasis is laid on software configuration management and testing activities. Selection and usage of CASE tool as well as working in teams in conformance with predefined quality criteria play a major role.
3	**Recommended prerequisite for participation** Introduction to Computer Science for Engineers as well as basic knowledge of Java
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Wi-ETiT, Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/se_ii/

Courses

Course Nr. 18-su-2010-vl	**Course name** Software-Engineering - Maintenance and Quality Assurance		
Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Marvin Ruland		**Type** Lecture	**SWS** 3
Course Nr. 18-su-2010-ue	**Course name** Software-Engineering - Maintenance and Quality Assurance		
Instructor Prof. Dr. rer. nat. Andreas Schürr, M.Sc. Sebastian Marvin Ruland		**Type** Practice	**SWS** 1

Module name Industrial Colloquium					
Module Nr. 18-dt-2010	**Credit Points** 2 CP	**Workload** 60 h	**Self study** 30 h	**Duration** 1	**Cycle offered** SoSe
Language German			**Module owner** Prof. Dr. rer. nat. Florian Steinke		

1 Content

To get an idea about current trends in industry. In addition, to give a glimpse of job opportunities the industry will provide after graduation. Acquired competences are:

- Active knowledge about industry trends and applications in multimedia communications
- Build contact with persons from various important companies
- Presentation skills improvement

2 Learning objectives / Learning Outcomes

Today, the Internet is much more than just a browser window on your desktop-PC. It is a part of our everyday life and has become ubiquitous thanks to smartphones, tablet-PCs and laptops. This pervasiveness of the Internet requires tremendous effort on the provider side. This is due to the fact that the Internet itself is a communication system with a vast number of mechanisms running on different functional layers. With the rapid increase of mobile devices, traffic consumption, and the sheer number of users, many of those mechanisms reach their limits. This problem becomes visible to the end user, if, for example, large crowds of people suddenly overload the mobile communication infrastructure.

With the recently established collaborative research center MAKI (Multi-Mechanismen-Adaption für das künftige Internet) scientists of TU Darmstadt study the possibilities of coordinated and automated transitions between different mechanisms of a communication system. Thereby, the Future Internet will be able to react to changes by, for example, switching from the mobile communication infrastructure to a local ad-hoc network between users if the demand by users exceeds the resources of the available infrastructure. In this year's industrial colloquium, partners from the industry present their visions, challenges and solutions regarding the Future Internet. Additionally, researches from TU Darmstadt provide insights into current scientific work in the context of the collaborative research center MAKI.

3 Recommended prerequisite for participation

Mandatory: Basic knowledge in Information Systems and Commubnication Systems. The sutdent has to be capeable to understand the technical aspects and to summerize them in a written report as a short paper.

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

Courses

	Course Nr.	Course name		
	18-dt-2010-ko	Industrial Colloquium		
	Instructor Prof. Dr. rer. nat. Florian Steinke, Prof. Dr. rer. nat. Andreas Schürr, Prof. Dr.-Ing. Ralf Steinmetz, Prof. Dr.-Ing. Klaus Hofmann, Prof. Dr.-Ing. Christian Hochberger		**Type** Colloquy	**SWS** 2

2 Optional Modules

2.1 DT I: Information Technology - Lectures

Module name Wireless Network for Emergency Response: Fundamentals, Design, and Build-up from Scratch						
Module Nr. 20-00-0780	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** Every 2. Sem.	
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Max Mühlhäuser			
1	**Content** The communication capabilities among the population is of utmost importance to respond to crises. This course will discuss how to build wireless communication systems from scratch, i.e. under the assumption that no communication infrastructure is left intact as a result of the crisis. The course introduces the theoretical basis from the fields of amateur radio as well as communication systems. It deepens these fields with the knowledge to design and build communication networks for times of crisis. The discussed technologies will span from local to global wireless communications without need of further infrastructure. Theoretical exercises as well as experimentation, the design and building of electrical circuits and the analysis of wireless technology under laboratory conditions deepen the understanding of the subject. Course contents: - Signals, signal propagation, antennas, basics of electrical engineering - Modulation schemes in analog and digital systems (OFDM, ATV/SSTV, Packet Radio, SSB, ...) - System aspects for communication in times of crisis - Design and practical realization from scratch of wireless communication systems						
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students have theoretical and practical knowledge in the area of wireless and infrastructureless communication for emergency response. They understand the most important physical and electrotechnical basics of wireless communications and know wireless transmission mechanisms in theory and practice. They are able to build a wireless communication system from scratch and operate it. The students acquire competences in the area of amateur radio and software defined radio technology.						
3	**Recommended prerequisite for participation**						
4	**Form of examination** Module Eccompanying Examination: • [20-00-0780-iv] (Technical Examination, Written/Oral Examination, Standard BWS)						
5	**Grading** Module Eccompanying Examination: • [20-00-0780-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)						
6	**Usability of this module**						

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Selected and given in lecture.

Courses

	Course Nr.	**Course name**		
	20-00-0780-iv	Wireless Network for Emergency Response: Fundamentals, Design, and Build-up from Scratch		
	Instructor Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		**Type** Integrated Course	**SWS** 3

Module name					
Real-Time Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-2020	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** The lecture basically covers a model-driven software engineering process which is specially customized for real-time systems. This process is more deeply explored in the exercise using an automotive example. A focus is laid on object-oriented techniques. In this context, a real-time specific state-of-the-art CASE tool is introduced and used. Furthermore, fundamental characteristics of real-time systems and system architectures are introduced. Scheduling algorithms are discussed to get insights into real-time operating systems. Finally, a comparison between the Java programming language and its expansion for real-time operating systems (RT Java) will conclude the lecture.
2	**Learning objectives / Learning Outcomes** Students, who have successfully attended this lecture have acquired skills needed for the model-driven and object-oriented development of embedded real-time systems. This includes a deeper understanding of the following topics: • classification of real-time systems • create and analyze executable models • application of real-time scheduling algorithms • evaluation and comparison of pros/cons of real-time programming languages as well as real-time operating systems
3	**Recommended prerequisite for participation** Basic knowledge of software engineering techniques and excellent knowledge of at least one object-oriented programming language (preferably Java)
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, BSc iST, MSc Wi-ETiT, BSc Informatik
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/es/

Courses

Course Nr. 18-su-2020-vl	**Course name** Real-Time Systems		
Instructor Prof. Dr. rer. nat. Andreas Schürr		**Type** Lecture	**SWS** 3
Course Nr. 18-su-2020-ue	**Course name** Real-Time Systems		
Instructor Prof. Dr. rer. nat. Andreas Schürr		**Type** Practice	**SWS** 1

Module name					
High-Level Synthesis					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2020	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Christian Hochberger		

1 Content

- Mapping of behavioral descriptions (e.g. in the form of program fragments) on FPGA and CGRA structures
- Sub-tasks allocation, scheduling, binding
- Exact or heuristic solutions
- Design principles of heuristic solutions

2 Learning objectives / Learning Outcomes

Students that have completed this module know alternative approaches for all of the tasks of the high level synthesis and can select appropriate ones for specific applications. They can evaluate the memory and time complexity of the given algorithms. They are enabled to adapt the algorithms for new constraints and new target technologies.

3 Recommended prerequisite for participation

Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc iCE

7 Grade bonus compliant to §25 (2)

8 References

English slides can be obtained through Moodle.

Courses

Course Nr.	Course name		
18-hb-2020-vl	High-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	3
Course Nr.	**Course name**		
18-hb-2020-ue	High-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Practice	1

Module name					
Communication Networks IV					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2030	3 CP	90 h	60 h	1	WiSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The lecture communication networks IV deals with modelling and performance evaluation of computer networks and communication systems. The emphasis is on current analytical approaches. Owing to these methods a fundamental understanding of major performance related aspects in networking is achieved and basic knowledge for planning, optimization and advancement of communications networks is provided. The relevance and implications of individual theories are illustrated using examples which are drawn mainly from the Internet. Apart from analytical methods the lecture gives an introduction to simulation of communication networks as well as measuring in real or prototypical systems and testbeds. In addition to well-known methods and their applications selected aspects of current research questions will be elaborated on.

Topics of the lecture are:

- Introduction to performance evaluation and applications
- Leaky bucket traffic regulators, deterministic traffic models, deterministic and empirical envelopes
- Scheduling, generalized processor sharing
- Network calculus, min-plus systems theory, deterministic performance bounds
- Poisson processes, Markov-chains, classical queuing theory, M|M|1 and M|G|1 models
- Modeling of packet data traffic, self-similarity
- Effective bandwidths, moment generating functions, statistical multiplexing
- Statistical network calculus, effective envelopes, effective performance bounds
- Simulation, generation of random numbers, distributions, confidence intervals
- Instrumentation, measurements, bandwidth estimation in the Internet

2 Learning objectives / Learning Outcomes

Students attending this lecture obtain an overview on the impact, fundamental methods, and important applications of performance evaluation of communication networks. They are acquainted with characteristic mechanisms and scheduling algorithms used in quality of service networks and are able to explain their functionality in terms of network calculus and the framework of min-plus systems theory. In addition to basic queuing theory the students acquire sound knowledge of the theory of effective bandwidths and thus exhibit a theoretically founded understanding of statistical multiplexing. Beyond analytical methods, the students gain insight into simulation as well as selected measurement methods and tools used in real networks. They are able to define the scope of individual theories and methods, select suitable, problem tailored techniques, apply these to typical problems, and draw relevant conclusions.

3 Recommended prerequisite for participation

Basic courses of the first 4 semesters are required. Knowledge of lectures Communication Networks I and II are recommended.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

Wi-CS, Wi-ETiT, BSc/MSc CS, MSc ETiT, MSc iST

7 Grade bonus compliant to §25 (2)

8	**References** Ausgewählte Kapitel aus folgenden Büchern: • J.-Y. Le Boudec, P. Thiran: “Network Calculus: A Theory of Deterministic Queuing Systems for the Internet”, Springer LNCS 2050, http://ica1www.epfl.ch/PS_files/netCalBookv4.pdf, 2004. • A. Kumar, D. Manjunath, J. Kuri: "Communication Networking: An Analytical Approach", Morgan Kaufmann, 2004. • A. M. Law, W. D. Kelton: "Simulation, Modeling and Analysis", McGraw Hill, 3rd Ed., 2000. • Selected Journal Articles and Conference Papers

Courses

Course Nr.	**Course name**		
18-sm-2030-vl	Communication Netzworks IV: Performance Evaluation of Communication Networks		
Instructor		**Type**	**SWS**
Dr.-Ing. Amr Rizk, Prof. Dr.-Ing. Ralf Steinmetz		Lecture	2

Module name					
Low-Level Synthesis					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-hb-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Christian Hochberger		

1 Content

The module deals with synthesis steps on all abstraction layers below the register transfer level focusing on approaches suitable for FPGAs. At the logic level different types of minimization are explained (exact and heuristic two level minimizations, exact and heuristic multi level logic minimizations). The transition to the technology level is achieved by different decomposition and structural mapping techniques (FlowMap). Place&Route add geometric information to the technology mapped circuit. Analytical and heuristic placers are discussed (Simulated Annealing, Genetic Placers) and routing is illustrated through the PathFinder algorithm.

2 Learning objectives / Learning Outcomes

After completion of the module, students are enabled to investigate synthesis approaches for low level synthesis tasks. They can evaluate these approaches regarding their time and space complexity, as well as regarding their applicability to specific implementation technologies.
Students can apply these approaches to new architectures and technologies.

3 Recommended prerequisite for participation

Knowledge of hardware synthesis on the basis of at least one hardware description language is required (e.g. Reese/Thornton: Introduction to Logic Synthesis Using Verilog Hdl oder Brown/Vranesic: Fundamentals of Digital Logic with VHDL Design). The student should have basic knowledge of at least one object oriented programming language, preferably Java

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

A script of the lecture (in German) and English foils can be obtained from here: http://www.rs.tu-darmstadt.de/

Courses

Course Nr.	Course name		
18-hb-2010-vl	Low-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Lecture	3
Course Nr.	**Course name**		
18-hb-2010-ue	Low-Level Synthesis		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Christian Hochberger		Practice	1

Module name					
Microprocessor Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2040	4 CP	120 h	75 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Microprocessor Architectures, DSP Architectures and Hardware related Programming
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • gain the overview on the fundamentals of computer architecture and the different processor classes (RISC, CISC, Mikrocontroller, CPU, DSP), • understand the central building blocks of a CPU • understand the major properties of the required semiconductor memories, I/O blocks and data busses (USB, PCI, RS232), • understand the most commonly used Interrupt- and Trap-handling algorithms, • know the common software development methodologies for microcontrollers (assembler, pseudooperations, makros, subprograms and subroutines), • understand the most important fundamentals of hardware oriented programming using C.
3	**Recommended prerequisite for participation** Basics of Computer Architectures
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr. 18-ho-2040-vl	**Course name** Microprocessor Systems		
Instructor Dr.-Ing. Matthias Rychetsky		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2040-ue	**Course name** Microprocessor Systems		
Instructor Dr.-Ing. Matthias Rychetsky		**Type** Practice	**SWS** 1

Module name					
Mobile Networking					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0748	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr.-Ing. Thorsten Strufe		

1 Content

Mobile communications and wireless networking technology has seen a thriving development in recent years. The integrated course addresses the characteristics/principles of mobile networks in detail, and practical solutions are presented. Hereby our focus is on the network layer, which is often regarded as the glue of communication systems. In addition to describing the state of the art in technology we discuss actual research problems and learn about methodologies to approach such problems systematically. The contents of the course will be deepended by exercises.

Course contents:

- Introduction to mobile and wireless communications: Applications, history, market vision
- Overview of wireless transmission: frequencies & regulations, signals, antennas, signal propagation, multiplexing, modulation, spread spectrum, cellular systems
- Medium access control in the wireless domain: SDMA, FDMA, CDMA TDMA (fixed, Aloha, CSMA, DAMA, PRMA, MACA, collision avoidance, polling)
- Wireless local area networks: IEEE 802.11 standard including physical layer, MAC layer and access schemes, quality of service and power management
- Wireless metropolitan area networks: Wireless mesh networks, IEEE 802.16 standard including modes of operation, medium access control, quality of service and scheduling
- Mobility at network layer: Concepts to support mobility on various layers, Mobile IP
- Ad hoc networks: Terminology, basics and applications, characteristics of ad hoc communication, ad hoc routing paradigms and protocols
- Performance evaluation of mobile networks: Overview of performance evaluation, systematic approach / common mistakes and how to avoid them, experimental design and analysis
- Mobility at transport layer: Variants of TCP (indirect TCP, snoop TCP, mobile TCP, wireless TCP)
- Mobility at application layer. Outlook: Applications for mobile networks and wireless sensor networks

2 Learning objectives / Learning Outcomes

After successfully attending the course, students have an in-deep knowledge on the working of mobile communication networks. They have gained insight into media access control mechanisms dedicated to wireless communication and have a thorough understanding of mechanisms based on the network and the transport layers, with a focus on ad hoc and mesh networks. Moreover, the students have acquired knowledge about the connections between the different protocol layers and are able to apply the acquired knowledge on methodological analysis of real communication systems. The students are therefore be conversant with the characteristics and basic principles of wireless and mobile communications in theory and practice. The exercise-parts of the integrated course deepen the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.

3 Recommended prerequisite for participation

Basic courses in Communication Networks are recommended.

4 Form of examination

Module Eccompanying Examination:

- [20-00-0748-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:

- [20-00-0748-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Selected literature, details are given in lecture.

Courses

Course Nr.	**Course name**		
20-00-0748-iv	Mobile Networking		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Thorsten Strufe		Integrated Course	4

Module name Learning and Educational Technologies					
Module Nr. 20-00-0773	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		

1	**Content** Digital applications and the Internet are changing the way we learn. If digital teaching and learning applications are designed appropriately, they offer a wide range of possibilities. The module aims to impart basic knowledge about the most important aspects of system design and about technologies needed for modern, web-based and mobile learning applications. Important theoretical foundations for the design of learning applications are learning theories. Therefore, learning theories are briefly discussed in the context of this module. The focus of the module is on adaptive learning applications. Different methods for the realization of adaptive learning applications will be presented. Frequently, Natural Language Processing and Artificial Intelligence methods are used for this purpose. In this context, current research work is considered. The module also focuses on the design of learning applications for individual and cooperative learning in various fields of application (e.g. school, university, vocational education and lifelong learning). Examples from current research projects as well as teaching/learning practice are presented. In addition, methods for the evaluation of learning applications are considered.
2	**Learning objectives / Learning Outcomes** After completion of the module, students will be able to analyze and design applications for knowledge acquisition and learning based on different design patterns and technologies. They will be able to decide on information representation (data level), design of functionalities (application level), and selection/configuration of algorithms to support platform users concerning challenges in the learning process. Students are capable to consider techniques of adaptation to learners needs and will know appropriate evaluation methods to measure the qualities and effects of learning applications and the algorithms and methods used in the learning applications.
3	**Recommended prerequisite for participation** Basic knowledge of Machine Learning and Natural Language Processing is desirable but not a prerequisite. For students who do not meet these requirements, we offer short learning modules that allow an understanding of the application-specific mechanisms.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0773-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0773-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik Kann in anderen Studiengängen verwendet werden.
7	**Grade bonus compliant to §25 (2)**
8	**References**
Courses	

	Course Nr.	Course name		
	20-00-0773-iv	Learning and Educational Technologies		
	Instructor Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		Type Integrated Course	SWS 4

Module name					
Software Defined Networking					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2280	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with topics in the area of software defined networking:

- SDN Data Plane
- SDN Control Plane
- SDN Application Plane
- Network Function Virtualization
- Network Virtualization and Slicing
- QoS and QoE in Software Defined Networks

2 Learning objectives / Learning Outcomes

Students will get a deep insight into Software Defined Networking as well as underlying technologies and applications.

3 Recommended prerequisite for participation

Basic courses of the first 4 semesters are required. Knowledge of lectures Communication Networks I and II are recommended.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, BSc/MSc iST, MSc Wi-ETiT, CS, Wi-CS

7 Grade bonus compliant to §25 (2)

8 References

Textbooks as indicated.
Slides and paper copies as necessary.

Courses

Course Nr.	Course name		
18-sm-2280-vl	Software Defined Networking		
Instructor		**Type**	**SWS**
Prof. Dr. Boris Koldehofe, M.Sc. Ralf Kundel		Lecture	2
Course Nr.	**Course name**		
18-sm-2280-ue	Software Defined Networking		
Instructor		**Type**	**SWS**
Prof. Dr. Boris Koldehofe, M.Sc. Ralf Kundel		Practice	2

Module name					
Computer Aided Design for SoCs					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2200	5 CP	150 h	90 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** CAD-Concepts for the design and simulation of integrated system-on-chips
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to understand • The most important design and verification abstractions as well as the design flow for the design of integrated electronic systems, • Selected algorithms for optimization, simulation and solving of design tasks, • Advanced methods for the design and simulation of analog integrated circuits in modern CMOS technologies, • Advanced concepts of hardware description languages and their concepts (Verilog, VHDL, Verilog-A, Verilog-AMS, System-Verilog)
3	**Recommended prerequisite for participation** Lecture "Advanced Digital Integrated Circuit Design" (can be attended in parallel) and „Analog Integrated Circuit Design" and "Logic Design"
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Duration: 90 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Written Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc MEC, MSc Wi-ETiT, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr. 18-ho-2200-vl	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2200-ue	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Practice	**SWS** 1
Course Nr. 18-ho-2200-pr	**Course name** Computer Aided Design for SoCs		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Internship	**SWS** 1

Module name Industrial Electronics					
Module Nr. 18-ho-2210	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** WiSe
Language German and English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Typical Struture of Industrial Electronics Components. Characteristics of Typical Building Blocks (Digital Core, Sensor Frontend, Actuator Frontend, Supply and Reference Level), Functioning of Relevant Field Bus Systems, Knowledge of Relevant Standards and Technical Regulations.
2	**Learning objectives / Learning Outcomes** After successfull completion of the module, students are able to: 1. understand the use of electronic components in typical industrial environments, 2. understand the function of the building blocks of typical IE comonents, 3. deeply understand the functioning of analog bulding blocks, 4. understand relevant field bus systemes, 5. understand the regulatory and technical standards of industrial electronics components.
3	**Recommended prerequisite for participation** Lecture “Elektronik“ and “Analog IC Design”
4	**Form of examination** Module Final Examination: • Module Examination (Technical Examination, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Technical Examination, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, M.Sc. iCE, M.Sc. MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** • Dietmar Schmid, Gregor Häberle, Bernd Schiemann, Werner Philipp, Bernhard Grimm, Günther Buchholz, Jörg Oestreich, Oliver Gomber, Albrecht Schilling: „Fachkunde Industrieelektronik und Informationstechnik“; Verlag Europa-Lehrmittel, 11 th Ed. 2013. • Gunter Wellenreuther, Dieter Zastrow; „Automatisieren mit SPS – Theorie und Praxis“; Springer Verlag, 6 th Ed. 2015. • Ulrich Tietze, Christoph Schenk, Eberhard Gamm: „Halbleiter-Schaltungstechnik“; Springer Verlag, 15 th Ed. 2016.

Courses

Course Nr. 18-ho-2210-vl	**Course name**		
Instructor Dr.-Ing. Roland Steck		**Type** Lecture	**SWS** 2
Course Nr. 18-ho-2210-ue	**Course name**		
Instructor Dr.-Ing. Roland Steck		**Type** Practice	**SWS** 1

Module name					
Energy Management and Optimization					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-st-2010	6 CP	180 h	120 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Florian Steinke		

1 Content

The lecture reviews the different levels of energy management. It then focuses on economic dispatch and discusses its different use cases like optimization of self-consumption, virtual power plants, electric vehicle load management or multi-modal neighborhood optimization. Relevant knowledge about the components to be controlled as well as the markets to be addressed is explained.

After this introduction to economic dispatch's application environment, the lecture focuses on the methods employed. The underlying mathematical formulations as different types of optimization problems (LP, MILP, QP, stochastic optimization) are reviewed. In parallel, a practical introduction to numerical optimization is given (descent algorithms, convergence, convexity, programming languages for the formulation of optimization problems). Moreover, an introduction into simple methods for the prognosis of future values (linear regression) is provided.All methodological learning is accompanied by hands-on exercises using the Matlab/Octave and the GAMS/AMPL software environments.

2 Learning objectives / Learning Outcomes

Students know the different use cases and formulations of economic dispatch. They have a basic understanding of the typically employed optimization methods and are able to judge the quality of the achieved results.

Moreover, students are independently able to formulate (energy) optimization problems and solve them with the tool GAMS/AMPL.

3 Recommended prerequisite for participation

Standard knowledge of linear algebra and multivariate analysis as well as basic knowledge in the use of Matlab/Octave is required. Knowledge of the modules „Kraftwerke & EE“ or „Energiewirtschaft“ is helpful but not necessarry.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iST, MSc Wi-ETiT, MSc CE

7 Grade bonus compliant to §25 (2)

Improvement of grades up to 0.4 compliant to APB §25(2) through bonus system for re-gular attention of exercises and practical courses

8 References

Boyd, Vandenberghe: Convex Optimization, Cambridge University Press, 2004A GAMS Tutorial by Richard E. Rosenthal, https://www.gams.com/24.8/docs/userguides/userguide/_u_g__tutorial.html

Courses

Course Nr.	Course name		
18-st-2010-vl	Energy Management and Optimization		
Instructor		**Type**	**SWS**
Prof. Dr. rer. nat. Florian Steinke		Lecture	2

	Course Nr. 18-st-2010-pr	**Course name** Energy Management and Optimization Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Internship	**SWS** 1
	Course Nr. 18-st-2010-ue	**Course name** Energy Management and Optimization		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Practice	**SWS** 1

Module name					
Machine Learning & Energy					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-st-2020	6 CP	180 h	120 h	1	WiSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Florian Steinke		

1 Content

The analysis and interpretation of data becomes ever more important, also for engineers. Digitalization and Smart Grids are terms to describe a host of novel data-based services in the field of generation, distribution, consumption and marketing of (renewable) energy. The lecture presents the recent developments and their underlying principles of machine learning technology.

For a start we will describe the different problem settings of machine learning in a structured way (classification, regression, clustering, dimensionality reductions, time series models, ...) and present for each setting relevant applications from the energy sector (prediction of renewable energy or consumption in multimodal energy systems, fault detection and prediction, data visualization, robust investments decisions, customer analysis, probabilistic load flow, ...).

Thereafter we will briefly review necessary tools from optimization and probability theory, as well as introduce probabilistic graphical models. With these tools we will then study for each problem setting one or more machine learning algorithms in detail, together with use cases from the energy domain. Classic algorithms will be developed (e.g. linear regression, k-means, principal component analysis, ...) as well as modern ones (e.g. SVMs, Deep Learning, Collaborative filtering, ...). Practical exercise with Matlab will deepen the understanding and support student's active knowledge.

2 Learning objectives / Learning Outcomes

Students understand important machine learning problem settings and some key algorithms for each task. They know common applications thereof in the energy domain. Moreover, the students are able to apply and adapt those methods independently to new applications (not only from the energy domain).

3 Recommended prerequisite for participation

- Good knowledge of linear algebra and the foundations of numerical optimization (e.g. from the course 18-st-2010 Energieanagement & Optimierung)
- Using Matlab for programming the practical examples should pose no difficulty. A block tutorial on the use of Matlab is offered as 18-st-2030 Matlab Grundkurs.

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc etit, MSc iST, MSc Wi-etit, MSc CE

7 Grade bonus compliant to §25 (2)

Notenverbesserungen bis zu 0,4 nach APB §25(2) durch Bonus für regelmäßig besuchte Übungs-/Praktikumstermine und mindestens einmaliges Vorrechnen in den Übungen

8 References

- A Géron: Hands on Machine Learning with scikit-learn and Tensorflow, 2017
- Friedman, Hastie, Tibshirani: The elements of statistical learning, 2001
- Koller, Friedmann: Graphical Models, 2009

Courses

	Course Nr. 18-st-2020-vl	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Lecture	**SWS** 2
	Course Nr. 18-st-2020-ue	**Course name** Machine Learning & Energy		
	Instructor Prof. Dr. rer. nat. Florian Steinke		**Type** Practice	**SWS** 1
	Course Nr. 18-st-2020-pr	**Course name** Machine Learning & Energy Lab		
	Instructor Prof. Dr. rer. nat. Florian Steinke, M.Sc. Tim Christian Janke		**Type** Internship	**SWS** 1

Module name Machine Learning in Information and Communication Technology (ICT)					
Module Nr. 18-kp-2110	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr. techn. Heinz Köppl		

1 Content

The module provides an introduction to the emerging field of machine learning from an engineering perspective. Important models and learning methods are presented and exemplified through problems from information and communication technology.

- Fundamentals of probability theory and multivariate statistics
- Taxonomy of machine learning problems and models (supervised, unsupervised, generative, discriminative)
- Regression and classification: theory, methods and ICT applications
- Dimensionality reduction, clustering and big data analytics: methods and application in communications and signal processing
- Probabilistic graphical models: categories, inference and parameter estimation
- Fundamentals of Bayesian inference, Monte Carlo methods, Bayesian non-parametrics
- Fundamentals of convex optimization: Solution methods and application in communications
- Approximate algorithms for scalable Bayesian inference; application in signal processing and information theory (e.g. decoding of LDPC codes)
- Hidden Markov models (HMM): Theory, Algorithms and ICT applications (e.g. Viterbi decoding of convolutional codes)
- High-dimensional statistics (“large p small n” setting), learning dependency structure in high-dimensional data, learning causality relations from observational data.
- Sparse estimation, random projections, compressive sensing: Theory and applications in signal processing
- Deep neural networks (deep learning): Models, learning algorithms, libraries and ICT applications

2 Learning objectives / Learning Outcomes

Students are able to interpret and categorize specific engineering problems from the ICT domain in terms of machine learning problems.
They are able to reduce such problems to standard machine learning problems and are able to determine suitable solution methods for them.
They are able to implement all necessary algorithms from scratch, but they are also familiar with the state-of-the-art libraries in machine learning.
They are able to determine the involved computational complexity of a method and choose an appropriate solution algorithms based on application constraints.
They are able to apply the acquired methods to other domains, such as data analysis in biomedical engineering, analysis of social network data, etc.

3 Recommended prerequisite for participation

Good command of Matlab (for instance knowledge from course 18-st-2030 Matlab Grundkurs) and engineering mathematics

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Optional, Weighting: 100 %)

6 Usability of this module

MSc etit, BSc/MSc iST, MSc iCE, MSc CE

7	**Grade bonus compliant to §25 (2)**			
8	**References** • Kevin P. Murphy. Machine Learning – A probabilistic perspective, MIT Press, 2012 • Christopher M. Bishop. Pattern recognition and Machine Learning, Springer, 2006 • Peter Bühlmann und Sara van de Geer. Statistics of high-dimensional data – Methods, theory and applications, Springer, 2011			
Courses				
	Course Nr. 18-kp-2110-vl	**Course name** Machine Learning in Information and Communication Technology (ICT)		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein		**Type** Lecture	**SWS** 2
	Course Nr. 18-kp-2110-pr	**Course name** Machine Learning in Information and Communication Technology (ICT) Lab		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein		**Type** Internship	**SWS** 1
	Course Nr. 18-kp-2110-ue	**Course name** Machine Learning in Information and Communication Technology (ICT)		
	Instructor Prof. Dr. techn. Heinz Köppl, Prof. Dr.-Ing. Anja Klein		**Type** Practice	**SWS** 1

Module name Modelling and simulation of circuits					
Module Nr. 18-sc-2010	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 75 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Sebastian Schöps		

1 Content

The content of this course is the following:

- Circuit interpretation as directed graphs
- Modified nodal and loop analysis
- Flux and charge oriented formulations
- Differential algebraic equations
- Linear system solver
- Numerical solution of nonlinear systems
- Time-domain methods
- Frequency-domain solution
- Implementation of the numerical methods

2 Learning objectives / Learning Outcomes

Students understand the theoretical and numerical fundamentals of circuit simulation and how the equations can be derived from Maxwell's equations. Circuit properties can be expressed in tems of graph theory. The sparse systems of equations such as the flux/charge oreinted modified nodal analysis can be assembled. In order to solve the obtained systems, different numerical methods for the simulation of circuits are relevant. This includes methods for the solution of linear systems (direct and iterative solvers), root-finding algorithms for nonlinear systems and implicit time integration methods. Mathematical concepts such as stability, convergence order or complexity are known and can be employed to judge the advantages and disadvantages of the various methods. Eventually, the students are able to programm their own circuit simulator, that can return both frequency as well as time domain solutions of electric networks.

3 Recommended prerequisite for participation

18-hs-1070 Elektrotechnik und Informationstechnik I
18-gt-1020 Elektrotechnik und Informationstechnik II
20-00-0304 Allgemeine Informatik I
04-00-0112 Mathematik IV

4 Form of examination

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Duration: 20 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Technical Examination, Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

Grade bonus of 0,4 if correctly implemented programs are submitted

8 References

- L. W. Nagel, “SPICE2: A computer program to simulate semiconductor circuits”, University of Berkeley, Tech. Rep., 1975.
- C.-W. Ho, A. E. Ruehli, and P. A. Brennan, “The modified nodal approach to network analysis”, IEEE Trans. Circ. Syst., vol. 22, no. 6, pp. 504–509, Jun. 1975.
- J. Vlach, K. Singhal, Computer methods for circuit analysis and design. New York : Van Nostrand Reinold, 1983.

Courses

Course Nr.	**Course name**		
18-sc-2010-vl	Modelling and simulation of circuits		
Instructor		**Type** Lecture	**SWS** 2
Course Nr.	**Course name**		
18-sc-2010-ue	Modelling and simulation of circuits		
Instructor		**Type** Practice	**SWS** 1

2.2 DT II: Information Technology - Practical Courses, Seminars, Project seminars

Module name Advanced Integrated Circuit Design Lab						
Module Nr. 18-ho-2120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe	
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann			
1	**Content** Practical Design Tasks in Full Custom Design of Digital or Analog Ciruits using State-of-the-Art Commercial CAD Tools					
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. develop and verify transistor circuitry using Cadence 2. simulate logic and analog circuits (Pre- and Postlayout) 3. draw, verify and extract layout					
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design” or “Analog Integrated Circuit Design”					
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)					
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)					
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE					
7	**Grade bonus compliant to §25 (2)**					
8	**References** ADIC Lecture Slide Copies; John P. Uyemura: Fundamentals of MOS Digital Integrated Circuits; Neil Weste et al.: Principles of CMOS VLSI Design					
Courses						
	Course Nr. 18-ho-2120-pr	**Course name** Advanced Integrated Circuit Design Lab				
	Instructor Prof. Dr.-Ing. Klaus Hofmann			**Type** Internship	**SWS** 3	

Module name					
HDL Lab					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-1090	6 CP	180 h	135 h	1	SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Realisation of a VHDL- or Verilog-based VLSI System Design Project in a Team with industrial constraints
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to 1. design, optimize and verify a complex digital system (e.g. a pipelined CPU or signal processor) using Verilog or VHDL, 2. synthesize the HDL description using commercial CAD software to a gate level description
3	**Recommended prerequisite for participation** Mandatory Prerequisite: Lecture Computer Aided Design for System on Chips, At least one high-level Programming Language, Basic Know-How Linux/Unix, Computer Architectures
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** BSc/MSc ETiT, BSc/MSc Wi-ETiT, MSc iCE, BSc/MSc iST, BSc/MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Lecture slides „HDL: Verilog and VHDL“

Courses

	Course Nr.	**Course name**		
	18-ho-1090-pr	HDL Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Klaus Hofmann		Internship	3

Module name Multimedia Communications Lab II					
Module Nr. 18-sm-2070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with cutting edge development topics in the area of multimedia communication systems. Besides a general overview it provides a deep insight into a special development topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and basic scientific competences in one or more of the following topics:

- Network planning and traffic analysis
- Performance evaluation of network applications
- Discrete event simulation for network services
- Protocols for mobile ad hoc networks / sensor networks
- Infrastructure networks for mobile communication / mesh networks
- Context-aware communication and services
- Peer-to-peer systems and architectures
- Content distribution and management systems for multimedia / e-learning
- Multimedia authoring and re-authoring tools
- Web service technologies and service-oriented architectures
- Applications for distributed workflows

2 Learning objectives / Learning Outcomes

The ability to solve and evaluate problems in the area of design and development of future multimedia communication networks and applications shall be acquired. Acquired competences are:

- Design of complex communication applications and protocols
- Implementing and testing of software components for distributed systems
- Application of object-oriented analysis and design techniques
- Acquisition of project management techniques for small development teams
- Writing of software documentation and project reports
- Presentation of project advances and outcomes

3 Recommended prerequisite for participation

Keen interest to explore challenging topics which are cutting edge in technology and research. Further we expect:

- Solid experience in programming Java and/or C# (C/C++)
- Solid knowledge in object oriented analysis and design
- Solid knowledge in computer communication networks are recommended
- Lectures in Communication Networks I (II, III, or IV) are an additional plus

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

MSc ETiT, MSc iCE, BSc/MSc iST, Wi-ETiT, BSc/MSc CS, Wi-CS,

7 Grade bonus compliant to §25 (2)

8	**References** Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books: • Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887) • Christian Ullenboom: "Java ist auch eine Insel: Programmieren mit der Java Standard Edition Version 5 / 6" (ISBN-13: 978-3898428385) • Joshua Bloch: "Effective Java Programming Language Guide" (ISBN-13: 978-0201310054) • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course Nr.	**Course name**		
18-sm-2070-pr	Multimedia Communications Lab II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer		Internship	3

Module name Lab Exercise on Secure Mobile Networking					
Module Nr. 20-00-0552	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. rer. nat. Karsten Weihe		

1	**Content** The Lab Exercise on Secure Mobile Networking covers the applied software development as well as hardware-software development. Topic areas covered are communication networks, IT security, mobile networks and wireless communications as well as the combination of these. Goal is the solving of a given problem by implementation in software or hardware/software in a team. Course contents: - Solving of a problem in the area of communication networks, IT security, mobile networks and wireless communications - Survey on solution alternatives and discussion of pros and cons - Conception of a software architecture or a combined hardware-software architecture - Software/hardware design for the target platform - Prototypical realization on the target platform - Evaluation of the system with respect to performance aspects - Documentation of the implemented solution
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students have aquired the ability to solve problems in the area of secure mobile networking using software technology. The students have gained insight into the design/implementation of complex protocols or applications in one/multiple of the areas of communication networks, IT security, mobile netwokrs and wireless communications. They are able to implement the chosen protocols and application, and to test the functionality as well as to evaluate the performance. Students are able to document the developed software artefacts and to present the project progress and outcomes.
3	**Recommended prerequisite for participation** Successfull participation in an lecture of SEEMOO.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0552-pr] (Study Achievement, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0552-pr] (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be given in lab.
Courses	

	Course Nr.	Course name		
	20-00-0552-pr	Secure Mobile Networking Lab		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Matthias Hollick		Internship	4

Module name Project Seminar Design for Testability					
Module Nr. 18-ho-2130	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language English			**Module owner** Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation
2	**Learning objectives / Learning Outcomes** Learning advanced Methods for Testing Microchips after Manufacturing and Practical Application in small Design Scenarios, Final Presentation
3	**Recommended prerequisite for participation** Lecture “Advanced Digital Integrated Circuit Design”
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC, MSc EPE
7	**Grade bonus compliant to §25 (2)**
8	**References** Slide Copies

Courses

Course Nr. 18-ho-2130-pj	**Course name** Project Seminar Design for Testability		
Instructor Prof. Dr.-Ing. Klaus Hofmann		**Type** Project Seminar	**SWS** 3

Module name Autonomous Driving Lab I					
Module Nr. 18-su-2070	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe
Language German			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Content

- Hands-on programming experience with C++ in the development of embedded software systems for autonomous driving based on a model car
- Application of control methods from the area of autonomous driving
- Application of software engineering techniques (design, documentation, test, ...) of a non-trivial embedded software system with hard real-time requirements and limited resources (memory, ...)
- Use of a given software framework and further libraries including a modular (real-time) operating system
- Hands-on experience using source code management systems, time management and other project management tools
- Presentations of the project results

2 Learning objectives / Learning Outcomes

During this project seminar students gain practical experience in software development for embedded systems in the field of autonomous driving using a model car. In teamwork, they learn to cope with an extensive task. In order to solve this task they practice to use the theoretical knowledge available in the group (from other courses such as real-time systems, software engineering - introduction, C++ lab, digital control systems).

Students that have successfully participated in this project seminar are able to organize and set-up a non-trivial software project in an interdisciplinary team according to a given problem independently. The participants acquire the following skills in detail:

- Independent familiarization with a given software framework and ready-made libraries
- Transfer of theoretic knowledge into a software system
- Extensive use of tools for version, configuration, and change management
- Realistic time and resource management (project management)
- Development of hardware/software systems with C++ considering important limitations of embedded systems
- Planning and implementation of extensive quality assurance measures
- Collaboration and communication in and between teams

3 Recommended prerequisite for participation

Recommended prerequisites are:

- ETiT/DT, iST, Informatik, WI-ET/DT: Basic software technology knowledge and advanced knowledge of object-oriented programming languages (especially C++)

Additionally desired:

- Basic knowledge of the development of real-time systems or image processing
- ETiT/AUT, MEC: Basic knowledge in control engineering including state space control design, some additional basic knowledge in digital control design may be helpful

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

	Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)			
6	**Usability of this module** MSc ETiT, BSc iST			
7	**Grade bonus compliant to §25 (2)**			
8	**References** https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-i/ and Moodle			
Courses				
	Course Nr. 18-su-2070-pj	**Course name** Autonomous Driving Lab I		
	Instructor Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz, M.Sc. Stefan Tomaszek		**Type** Project Seminar	**SWS** 3

Module name Autonomous Driving Lab II					
Module Nr. 18-su-2100	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** SoSe
Language German and English			**Module owner** Prof. Dr. rer. nat. Andreas Schürr		

1 Content

2 Learning objectives / Learning Outcomes

Students learn to independently develop, implement and present new concepts and algorithms in the field of autonomous driving. Realistic problems from the Carolo Cup are solved with existing knowledge and skills practically and the implementation is ensured by quality assurance measures.
Students who have successfully participated in this project seminar are able to independently analyze and solve a complex and realistic task in the field of autonomous driving. The participants acquire the following skills in detail:

- Further development and optimization of an existing software system and the used algorithms independently
- Solving and implementation of non-trivial, realistic control engineering challenges
- Extensive use of tools for version, configuration, change, and quality assurance management
- Realistic time planning and resource allocation (project management)
- Further development and optimization of complex hardware/software systems under realistic environmental conditions
- Planning and implementation of extensive quality assurance measures
- Collaboration, communication and organization within the team

3 Recommended prerequisite for participation

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)

6 Usability of this module

7 Grade bonus compliant to §25 (2)

8 References

https://www.es.tu-darmstadt.de/lehre/aktuelle-veranstaltungen/ps-af-ii und Moodle

Courses

Course Nr. 18-su-2100-pj	**Course name** Autonomous Driving Lab II		
Instructor Prof. Dr. rer. nat. Andreas Schürr, Dr. Ing. Eric Lenz		**Type** Project Seminar	**SWS** 3

Module name					
Multimedia Communications Project Seminar II					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-sm-2080	6 CP	180 h	135 h	1	WiSe/SoSe
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

The course deals with cutting edge scientific and development topics in the area of multimedia communication systems. Besides a general overview it provides a deep insight into a special scientific topic. The topics are selected according to the specific working areas of the participating researchers and convey technical and scientific competences in one or more of the following topics:

- Network planning and traffic analysis
- Performance evaluation of network applications
- Discrete event simulation for network services
- Protocols for mobile ad hoc networks / sensor networks
- Infrastructure networks for mobile communication / mesh networks
- Context-aware communication and services
- Peer-to-peer systems and architectures
- Content distribution and management systems for multimedia / e-learning
- Multimedia authoring and re-authoring tools
- Web service technologies and service-oriented architectures
- Applications for distributed workflows

2 Learning objectives / Learning Outcomes

The ability to solve and evaluate technical and scientific problems in the area of design and development of future multimedia communication networks and applications using state of the art scientific methods shall be acquired. Acquired competences are:

- Searching and reading of project relevant literature
- Design of complex communication applications and protocols
- Implementing and testing of software components for distributed systems
- Application of object-oriented analysis and design techniques
- Acquisition of project management techniques for small development teams
- Systematic evaluation and analyzing of technical and scientific experiments
- Writing of software documentation and project reports
- Presentation of project advances and outcomes

3 Recommended prerequisite for participation

Keen interest to develop and explore challenging solutions and applications in cutting edge multimedia communications systems using scientific methods. Further we expect:

- Solid experience in programming Java and/or C (C/C++)
- Solid knowledge in object oriented analysis and design
- Basic knowledge of design patterns, refactoring and project management
- Solid knowledge in computer communication networks are recommended
- Lectures in Communication Networks I (II, III, or IV) are an additional plus

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6	**Usability of this module** Wi-CS, Wi-ETiT, BSc/MSc CS, MSc ETiT, MSc iST
7	**Grade bonus compliant to §25 (2)**
8	**References** Each topic is covered by a selection of papers and articles. In addition we recommend reading of selected chapters from following books: • Andrew Tanenbaum: “Computer Networks”. Prentice Hall PTR (ISBN 0130384887) • Raj Jain: "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling" (ISBN 0-471-50336-3) • Joshua Bloch: "Effective Java - Programming Language Guide" (ISBN-13: 978-0201310054) • Erich Gamma, Richard Helm, Ralph E. Johnson: "Design Patterns: Objects of Reusable Object Oriented Software" (ISBN 0-201-63361-2) • Martin Fowler: "Refactorings - Improving the Design of Existing Code" (ISBN-13: 978-0201485677) • Kent Beck: "Extreme Programming Explained - Embrace Changes" (ISBN-13: 978-0321278654)

Courses

Course Nr.	**Course name**		
18-sm-2080-pj	Multimedia Communications Project Seminar II		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer		Project Seminar	3

Module name Projektseminar Rekonfigurable Systems					
Module Nr. 18-hb-2040	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christian Hochberger		

1	**Content** Students will work in small groups in this course. Topics and application context will be defined individually for each group. All projects will follow the same approach. At first, the given problem will be described in a programmatic way. Following, it will be implemented by a reconfigurable system. Depending on the nature of the application, either predefined architectures will be used, parameterizable architectures will be adapted to the needs of the application or new architectures may be designed. The programmatic description will now be mapped (semi-)automatically to the chosen architecture with the help of the supporting tools. Usually, this requires to rewrite the programmatic description to better suit the tools. Finally, the solution will be evaluated using some benchmark data sets.
2	**Learning objectives / Learning Outcomes** Successful students will know how to use reconfigurable systems within a given application context. They can use tools to program these systems and know how to map an application onto a given reconfigurable architecture. They are capable to evaluate the performance critical parts of an application. They understand the implications of different coding styles for a particular task.
3	**Recommended prerequisite for participation** • Knowledge of reconfigurable devices (cf. course computer systems II) • Knowledge of computer architecture (cf. course computer systems I) • Solid programming skills (either in C or Java depending on the application scenario).
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc iST, MSc Informatik, MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be made available through the Moodle page for this course.

Courses

	Course Nr.	**Course name**		
	18-hb-2040-pj	Projektseminar Rekonfigurable Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Christian Hochberger		Project Seminar	3

Module name					
Project Seminar Energy Information Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-st-2040	6 CP	180 h	135 h	1	WiSe/SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Florian Steinke		

1	**Content** Students elaborate on a research-oriented subject in the area of computer-systems in a self-responsible manner. They present a written documentation and/or a presentation of the acquired advanced knowledge. They provide a set of alternative solutions to a given problem.
2	**Learning objectives / Learning Outcomes** Students are able to systematically develop design alternatives to a given problem. They learn to acquire the necessary fundamental knowledge in terms of references and terminology. The found solutions are reflected critically and the students decide for a suitable solution which they are able to argue for and accomplish.
3	**Recommended prerequisite for participation** no
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Optional, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Optional, Weighting: 100 %)
6	**Usability of this module** MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References**

Courses

	Course Nr.	**Course name**		
	18-st-2040-pj	Project Seminar Energy Information Systems		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Florian Steinke		Project Seminar	3

Module name Advanced Topics in Embedded Systems and Applications					
Module Nr. 20-00-1001	**Credit Points** 9 CP	**Workload** 270 h	**Self study** 180 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1 Content

The course covers current topics in research and development of computing systems and programming tools, including focused ones in the areas of embedded and application-specific architectures. The subjects are determined by current research efforts in the ESA group and are intended to guide students towards acquiring technical as well as introductory scientific skills, for example, including one or more of the following domains:

- Computing systems architecture at the processor and systems-level
- Design of digital electronic circuits and hardware systems
- Use of Field-Programmable Gate Arrays

Hardware/Software design and programming tools

- Operating systems and low-level programming

Hardware/Software Co-Design

Application-specific architectures and techniques

- Design and/or programming of compute accelerators
- Debugging and analysis techniques for hardware/software-systems

2 Learning objectives / Learning Outcomes

Participants are intended to acquire the skills necessary to quickly become familiar with a new domain and then solve a complex practical problem within that domain. These skills can include studies of scientific literature, surveying existing code-bases from the hardware/software domains, and the practical implementation of hardware and/or software systems. The final talk should show proficiency with basic presentation techniques.

3 Recommended prerequisite for participation

An interest to develop high-quality solutions in the assigned problem domain. For different domains, different pre-requisites will be required. These can include digital design, compiler construction, system-level and parallel programming. Such skills can be acquired by successfully completing the appropriate lectures.

4 Form of examination

Module Eccompanying Examination:

- [20-00-1001-pp] (Study Achievement, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:

- [20-00-1001-pp] (Study Achievement, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Informatjk
M.Sc Informatik
May be used in other degree programs.

7 Grade bonus compliant to §25 (2)

8 References

Courses

	Course Nr.	Course name		
	20-00-1001-pp	Advanced Topics in Embedded Systems and Applications		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Andreas Koch		Project	6

Module name					
Seminar Integrated Electronic Systems Design A					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-ho-2160	4 CP	120 h	90 h	1	WiSe/SoSe
Language			**Module owner**		
English			Prof. Dr.-Ing. Klaus Hofmann		

1	**Content** Research oriented Formulation of a Topic within the area of Microelectronics System Design; Creation of a written Documentation and Presentation; Team Work
2	**Learning objectives / Learning Outcomes** A student is, after successful completion of this module, able to • gain a deep understanding of the chosen research subject in the field of integrated electronic systems, • write an essay on the chosen subject in a comprehesive form and present the outcome to an audience
3	**Recommended prerequisite for participation** Advanced Digital Integrated Circuit Design, CAD Methods, Computer Architectures, Programming Know-How
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 45 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** MSc ETiT, MSc Wi-ETiT, MSc iCE, MSc iST, MSc MEC
7	**Grade bonus compliant to §25 (2)**
8	**References** Topic-oriented Materials will be provided

Courses

Course Nr.	Course name		
18-ho-2160-se	Seminar Integrated Electronic Systems Design A		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Klaus Hofmann		Seminar	2

Module name Multimedia Communications Seminar II					
Module Nr. 18-sm-2090	**Credit Points** 4 CP	**Workload** 120 h	**Self study** 90 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German and English			**Module owner** Prof. Dr.-Ing. Ralf Steinmetz		

1 Content

This seminar deals with current and upcoming trends relevant to the future development of multimedia communication systems. The educational objective of this seminar is to gain knowledge about future research trends in different areas. To this aim, an extensive literature research will be performed, as well as the writing-up of a report and the presentation of selected, high-quality research topics from current leading magazines, newspapers and conferences in the web technologies research area.
Some potential topics are:

- Knowledge & Educational Technologies
- Self organizing Systems & Overlay Communication
- Mobile Systems & Sensor Networking
- Service-oriented Computing
- Multimedia Technologies & Serious Games

2 Learning objectives / Learning Outcomes

Students shall acquire profound knowledge from current scientific publications, standards and literature on multimedia communication systems and applications which will build the future Internet. In so doing, the students will develop the following competencies:

- Search for and review relevant scientific literature.
- Analyse and evaluate complex technical and scientific information.
- Write technical and scientific abstracts and summary reports.
- Present technical and scientific information.

3 Recommended prerequisite for participation

Solid knowledge in computer communication networks. Lectures in Communication Networks I and II are recommended.

4 Form of examination

Module Final Examination:

- Module Examination (Study Achievement, Optional, Standard Grading System)

5 Grading

Module Final Examination:

- Module Examination (Study Achievement, Optional, Weighting: 100 %)

6 Usability of this module

CS, Wi-CS, ETiT, Wi-ETiT, MSc CS, MSc ETiT, MSc iST

7 Grade bonus compliant to §25 (2)

8 References

Depending on specific topic (selected articles of journals, magazines, and conferences).

Courses

Course Nr. 18-sm-2090-se	**Course name** Multimedia Communications Seminar II	
Instructor Prof. Dr.-Ing. Ralf Steinmetz, M.Sc. Julian Zobel, M.Sc. Daniel Bischoff, M.Sc. Tim Steuer	**Type** Seminar	**SWS** 2

Module name					
Seminar Software System Technology					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
18-su-2080	4 CP	120 h	90 h	1	SoSe
Language			**Module owner**		
German			Prof. Dr. rer. nat. Andreas Schürr		

1	**Content** In this course, the students produce scientific reports from changing subject areas. Each student has to explore a subject related to IT system development and produce a written report as well as a final talk with a presentation. A list of the subjects of the current semester is available at www.es.tu-darmstadt.de/lehre/sst.
2	**Learning objectives / Learning Outcomes** After a successful participation, the students will be able to explore an unknown topic under scientific aspects. The students learn to support the exploration by a literature research and to analyze the subject critically. They achieve the skills to present a definite subject in a written report as well as in an oral presentation.
3	**Recommended prerequisite for participation** Basic knowledge in software engineering and programming languages
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Duration: 30 min, Standard Grading System)
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc iST, BSc Informatik, MSc ETiT
7	**Grade bonus compliant to §25 (2)**
8	**References** www.es.tu-darmstadt.de/lehre/sst

Courses

	Course Nr.	**Course name**		
	18-su-2080-se	Seminar Software System Technology		
	Instructor		**Type**	**SWS**
	Prof. Dr. rer. nat. Andreas Schürr		Seminar	2

Module name Artificial Intelligence in Medicine Challenge					
Module Nr. 18-ha-2010	**Credit Points** 8 CP	**Workload** 240 h	**Self study** 180 h	**Duration** 1	**Cycle offered** WiSe/SoSe
Language German			**Module owner** Prof. Dr.-Ing. Christoph Hoog Antink		

1	**Content** Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.
2	**Learning objectives / Learning Outcomes** Within this module, students will work independently in small groups on a given problem from the realm of artificial intelligence (AI) in medicine. The nature of the problem can be the automatic classification or prediction of a disease from medical signals or data, the extraction of a physiological parameter, etc. All groups will be given the same problem but will have to develop their own algorithms, which will be evaluated on a hidden dataset. In the end, a ranking of the best-performing algorithms is provided.
3	**Recommended prerequisite for participation** • Basic programming skills in Python • 18-zo-1030 Fundamentals of Signal Processing
4	**Form of examination** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Standard Grading System) Report and/or Presentation. The type of examination will be announced in the beginning of the lecture.
5	**Grading** Module Final Examination: • Module Examination (Study Achievement, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** BSc/MSc (WI-)etit, AUT, DT, KTS BSc/MSc iST MSc iCE
7	**Grade bonus compliant to §25 (2)**
8	**References** • Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001. • Bishop, Christopher M. Pattern recognition and machine learning. springer, 2006.

Courses

Course Nr. 18-ha-2010-pj	**Course name** Artificial Intelligence in Medicine Challenge	
Instructor Prof. Dr.-Ing. Christoph Hoog Antink	**Type** Project Seminar	**SWS** 4

2.3 DT III: Computer Science

Module name Introduction to Cryptography					
Module Nr. 20-00-0085	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Content** Mathematical basic principles: - Calculations in congruence and residue class rings Basic principles of encryption: - Symmetric vs. asymmetric cryptosystems - Block and stream ciphers, AES, DES - Cryptanalysis - Probability and perfect security - Public-key encryption - RSA, Diffie-Hellman, ElGamal - Factoring large numbers - Discrete logarithms - Cryptographic hash functions - Digital signatures - Identification
2	**Learning objectives / Learning Outcomes** - understanding the mathematical foundations of cryptography such as calculations in congruence and residue class rings, factoring large numbers, probability theory and perfect security - understanding the principles of public and secret key encryption and relevant schemes including their security and efficiency - understanding the principles of digital signatures and the relevant schemes including their security and efficiency
3	**Recommended prerequisite for participation** - Linear Algebra for Computer Science - Funktionale und Objektorientierte Programmierkonzepte
4	**Form of examination** Module Eccompanying Examination: • [20-00-0085-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0085-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.

8	**References** - Johannes Buchmann: Einführung in die Kryptographie, 5. Auflage, Springer-Verlag, 2010, 278 p. ISBN: 978-3-642-11185-3 - Johannes Buchmann: Cryptographic Protocols. Vorlesungsskript (u.a. Undeniable, Fail-Stop und Blind Signatures) - Neal Koblitz: A Course in Number Theory and Cryptography, Springer Verlag, 1994 - Alfred J. Menezes, Paul C. van Oorschot, Scot A. Vanstone: Handbook of Applied Cryptography, CRC Press, 1997 (erhältlich als PDF) - Bruce Schneier: Applied Cryptography, John Wiley & Sons, Inc., 1994 - Douglas R. Stinson: Cryptography - Theory and Practice, CRC Press, 1995 - Gustavus J. Simmons: Contemporary Cryptology - The Science of Information Integrity, IEEE Press, 1992

Courses

Course Nr.	**Course name**		
20-00-0085-iv	Introduction to Cryptography		
Instructor		**Type** Integrated Course	**SWS** 4

Module name Advanced Compiler Construction					
Module Nr. 20-00-0701	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr.-Ing. Andreas Koch		

1	**Content** - Compilation and run-time environment for object-oriented programming languages - Control flow graphs as intermediate representations - Static dataflow analysis - Static single-assignment form - Eliminating total and partial redundancy - Scalar optimization - Register allocation - Scheduling - Loop optimization - Structure and organization of real compilers (e.g., phases, intermediate representations, compfile flow)
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students understand techniques for the compilation and execution of object-oriented programs at the machine-level. The can apply static dataflow analysis to control flow graphs and are practiced using their SSA form. They are familiar with optimizing techniques for a number of problems as well as fundamental algorithms for register allocation. They know the internal structure of real production-grade compilers.
3	**Recommended prerequisite for participation** Successfull participation of “Einführung in den Compilerbau”
4	**Form of examination** Module Eccompanying Examination: • [20-00-0701-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0701-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** Literature recommendations will be updated regularly, an example might be: Cooper/Torczon: Engineering a Compiler Muchnick: Advanced Compiler Design and Implementation Aho/Lam/Sethi/Ullman: Compilers - Principles, Techniques, and Tools
Courses	

	Course Nr.	Course name		
	20-00-0701-vl	Advanced Compiler Construction		
	Instructor		**Type**	**SWS**
	Prof. Dr.-Ing. Andreas Koch		Lecture	3

Module name					
Network Security					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0512	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
English			Dr.-Ing. Michael Kreutzer		

1 Content

The integrated course Network Security covers the principles and practice of computer and telecommunication network security with particular emphasis on Internet security. After transferring the fundamentals of IT security and cryptography to the networking domain, we follow a top-down approach to network security. Starting with the application layer, the course provides a detailed discussion of network security principles and protocols. In addition to well known mechanisms, selected recent developments in the area of network security will be examined.

Course contents:

- Network security: introduction, motivation, and challenges
- Fundamentals: a reference model for network security, security standards for networks and the Internet, security threats, attacks, services, and mechanisms
- Cryptographic foundations for networking security: symmetric crypto and its use in networks, public-key crypto and its use in networks, support functions to implement network security
- Application layer security
- Transport layer security
- Network layer security
- Link layer security
- Physical layer security and physical security
- Operational network security: firewalls, intrusion detection systems
- Selected topics in network security

2 Learning objectives / Learning Outcomes

After successfully attending the course, students have aquired an in-deep knowledge in the domain of communication network security with emphasis on Internet security. Students are able to apply and transfer the most important fundamentals from IT security and cryptography to the field of communication networks. Students are able to distinguish the most important basic techniques for securing communication networks. They have a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of network security and exhibit detailed theoretical and practical knowledge in this field. Additionally, students are able to describe recent developments in the area of network security (e.g. peer-to-peer security, mobile network security, etc.). The exercise deepens the theoretical foundations by means of exercises, which consist of literature, calculation as well as practical implementation/application examples.

3 Recommended prerequisite for participation

Knowledge in the area IT Security, Introduction to Cryptography and Communication Networks

4 Form of examination

Module Eccompanying Examination:

- [20-00-0512-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:

- [20-00-0512-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

	B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Charlie Kaufman, Radia Perlman, Mike Speciner: Network Security – Private Communication in a Public World, 2nd Edition, Prentice Hall, 2002, ISBN: 978-0-14-046019-6; additional texts may be announced

Courses

Course Nr.	**Course name**		
20-00-0512-iv	Network Security		
Instructor		**Type**	**SWS**
Dr.-Ing. Michael Kreutzer		Integrated Course	4

Module name Physical Layer Security in Wireless Systems					
Module Nr. 20-00-0745	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 135 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Dr.-Ing. Michael Kreutzer		

1	**Content** Physical layer security techniques promise information theoretic security on the physical layer for wireless communication. This integrated course discusses the theory and practice of physical layer security. The underlying theory is introduced and the application of these fundamentals towards practical solutions is discussed. Attacks against (practical) physical layer security techniques are presented. Theoretical and practical exercises as well as the presentation of selected recent research results by seminar talks of students further deepen the understanding of the subject matter. Course contents: - Properties of the physical layer - Fundamentals of information theoretic security and delineation from cryptography - Physical layer security techniques (such as cooperative jamming, orthogonal blinding, zero-forcing, interference alignment, key extraction) - Practical aspects of physical layer security techniques - Practical implementations of physical layer security techniques using software-defined radios - Selected current approaches to physical layer security
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students have a basic theoretical knowledge and an in-deep practical knowledge in the area of physical layer security. They are able to describe the most important information-theoretic basics as well as theory and practice of physical layer security techniques. They are able to analyze practical physical layer security techniques and describe their weaknesses. Students have competencies in the practical realization of physical layer security techniques using software-defined radios. They can independently acquire the current state of research on physical layer security and present the aquired knowledge in a comprehensible fashion.
3	**Recommended prerequisite for participation** Basics Mobile Networking
4	**Form of examination** Module Eccompanying Examination: • [20-00-0745-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0745-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

	Selected literature, will be given in lecture.

Courses

Course Nr. 20-00-0745-iv	**Course name** Physical Layer Security in Wireless Systems		
Instructor Dr.-Ing. Michael Kreutzer		**Type** Integrated Course	**SWS** 3

Module name					
Programming Massively Parallel Processors					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0419	6 CP	180 h	120 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. Bernt Schiele		

1	**Content** - foundations of massively parallel processors with a focus on modern accelerator hardware - parallel algorithms - efficient programming of massively parallel systems - practical programming projects co-advised by domain scientists
2	**Learning objectives / Learning Outcomes** After successful completion of the course, students are able to analyze problems in the context of massively parallel systems. They can develop novel applications and systematically improve their performance. They understand basic parallel algorithms and are able to independently understand and analyze current literature.
3	**Recommended prerequisite for participation** Programming skills in C/C++ Recommended: Systemnahe und Parallele Programmierung
4	**Form of examination** Module Eccompanying Examination: • [20-00-0419-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0419-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25(2) der 5. Novelle der APB und den vom FB 20 am 02.10.2012 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** Will be announced in lecture.

Courses

Course Nr.	Course name		
20-00-0419-iv	Programming Massively Parallel Processors		
Instructor		**Type**	**SWS**
		Integrated Course	4

Module name					
Network, Traffic and Quality Management for Internet Services					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0056	3 CP	90 h	60 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		

1	**Content** Introduction into management of Internet service provider (ISP-)networks for integrating IP service platforms with their quality and traffic profiles
2	**Learning objectives / Learning Outcomes** Course Content: Demands and measures for ensuring Quality-of-Service (QoS) ?Criteria from the applications & users view (QoE: Quality of Experience) ?IP QoS Architecture: Differentiated & Integrated Services ?QoS support & impact per application in the current IP traffic mix (Video streaming, VoIP, web browsing, downloads, social networking etc.) Quality support for IP services within ISP network infrastructures ?Impact of network and transport layer Routing (OSPF, BGP), Multiprotocol Label Switching (MPLS), TCP incl. failure handling and resilience ?Measurement, monitoring and optimization of IP traffic regarding QoS criteria Quality support in service overlays and on application layer ?Content Delivery Networks (CDN), clouds and Peer-to-Peer networks (P2P) incl. distributed caches, optimization of transport paths, scalability and ?IETF Standardization (CDN Interconnection, ALTO: Appl. Layer Traffic Opt.)
3	**Recommended prerequisite for participation** Prerequisites: Basic knowledge in computer science and Internet applications is required. The courses on Kommunikationsnetze I and II are recommended.
4	**Form of examination** Module Eccompanying Examination: • [20-00-0056-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0056-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module**
7	**Grade bonus compliant to §25 (2)**
8	**References** Will be given in lecture.

Courses

Course Nr.	Course name		
20-00-0056-vl	Network, traffic and quality management for Internet services		
Instructor		**Type**	**SWS**
		Lecture	2

Module name Serious Games					
Module Nr. 20-00-0366	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German and English			**Module owner** Prof. Dr. Bernt Schiele		

1	**Content** Introduction to the topic of “”Serious Games"": scientific and technical foundations, application areas and trends. Individual lectures include: * Introduction to Serious Games * Game Development, Game Design * Game Technology, Tools and Engines * Personalization and Adaptation * Interactive Digital Storytelling * Authoring and Content Generation * Multiplayer Games * Game Interfaces and Sensor Technology * Effects, Affects and User Experience * Mobile Games * Serious Games Application Domains and Best Practice Examples The exercise consists of theoretical and practical parts. Students are taught how to use a Game Engine.
2	**Learning objectives / Learning Outcomes** After successfully completing this course the students are able to explain the concept of “Serious Games” and can transfer it to different application domains (like education or health). They can describe the general approach for developing computer games and can apply basic principles of game design, personalisation / adaptation and interactive digital storytelling. Aside from that students are able to sketch out other current research questions regarding Serious Games as well as their solutions.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [20-00-0366-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0366-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik B.Sc. Computational Engineering M.Sc. Computational Engineering M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

	Will be given in lecture.

Courses			
	Course Nr. 20-00-0366-iv	**Course name** Serious Games	
	Instructor	**Type** Integrated Course	**SWS** 4

Module name					
Secure Mobile Systems					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0583	3 CP	90 h	60 h	1	Every 2. Sem.
Language			**Module owner**		
German and English			Prof. Dr.-Ing. Matthias Hollick		

1	**Content** The integrated course Secure Mobile Systems covers the topic area of security in wireless and mobile networks and communication systems. Fundamental topics will be enriched by current research. Course contents: - Security analysis and modelling of security threats in mobile and wireless systems - Selected attacks and security mechanisms specific to mobile and wireless systems - Security in wireless sensor networks - Security in wireless mesh networks - Threats against privacy and privacy-preserving mechanisms in mobile and wireless systems - Security in cellular networks (GSM, UMTS, LTE) - Security on the physical layer in mobile and wireless systems - Selected research topisc in mobile and wireless systems
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students have a specialized knowledge in the domain of security with emphasis on mobile, distributed, wireless communication networks. Students are able to apply and transfer the most important fundamentals from IT security, cryptography and traditional network security to the field of mobile systems. Students obtain a thorough understanding of security mechanisms on the different network layers (application layer, transport layer, network layer, link layer, physical layer). As a result, they are able to thoroughly discuss the characteristics and principles in the area of mobile system security and exhibit detailed theoretical and practical knowledge in this field.
3	**Recommended prerequisite for participation** Grundlagen der Netzsicherheit und der Mobilen Netze
4	**Form of examination** Module Eccompanying Examination: • [20-00-0583-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0583-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik Can be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

	Levente Buttyan, Jean-Pierre Hubaux: Security and Cooperation in Wireless Networks, Cambridge University Press, 2008, ISBN: 978-0-521-87371-0 (book is available online for download). Ausgewählte Buchkapitel und ausgewählte wissenschaftliche Veröffentlichungen.

Courses

Course Nr.	**Course name**		
20-00-0583-vl	Secure Mobile Systems		
Instructor		**Type**	**SWS**
Prof. Dr.-Ing. Matthias Hollick		Lecture	2

Module name					
Software Engineering - Design and Construction					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0341	8 CP	240 h	165 h	1	Every 2. Sem.
Language			**Module owner**		
English			Prof. Dr.-Ing. Ermira Mezini		

1 Content

The primary goal of the lecture is to teach students how to design modular software to get maintainable, reusable and extensible software systems.
As part of the lecture, the relation between advanced programming language features and software designs is discussed and also the impact of programming languages on the overall design.
The lecture will in particular discuss:
- Class design (principles) using advanced design patterns and advanced programming language features
- Package-level design (principles);
- High-level design using architecture styles;
- Documenting designs;
- Refactoring designs;
- Metrics to evaluate designs.

2 Learning objectives / Learning Outcomes

After the successful completion of the lecture students are able to perform the following tasks:
- They can analyze the design of existing systems with respect to their modularity and can propose refactorings to improve the modular structure.
- They understand the mid- and long-term issues of non-modular systems.
- They know advanced design patterns and can identify them in existing code and can also apply them to solve new design problems.
- They know well-established architectural styles and can apply them in familiar situations.
- They understand that a solution to a design problem may depend on the chosen programming language and to critically question related decisions.

3 Recommended prerequisite for participation

Successful completion of the lecture Software Engineering

4 Form of examination

Module Eccompanying Examination:
- [20-00-0341-iv] (Technical Examination, Written/Oral Examination, Standard BWS)

5 Grading

Module Eccompanying Examination:
- [20-00-0341-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)

6 Usability of this module

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik
Can be used in other degree programs.

7 Grade bonus compliant to §25 (2)

	In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References** - Bass, L.; Clements, P.; Kazman, R. ; Software Architecture in Practice, Addison-Wesley - Booch, G. Object-Oriented Analysis and Design with Applications. Addison-Wesley - Budd, T. Introduction to Object-Oriented Programming. 2nd. ed., Addison-Wesley - Buschmann, F. et al. Pattern-Oriented Software Architecture: A System of Patterns. John Wiley & Sons - Czarnecki, K. and Eisenecker, U. Generative Programming. Addison-Wesley - Garland, D. and Shaw, M. Software Architecture: Perspectives on an Emerging Discipline. Prentice Hall - Gamma, E. et al. Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley - Martin, Robert. Agile Software Development. Principles, Patterns, and Practices. Pearson US Imports & PHIPEs - Riel, A. Object-Oriented Design Heuristics. Addison-Wesley

Courses

Course Nr. 20-00-0341-iv	**Course name** Software Engineering - Design and Construction		
Instructor		**Type** Integrated Course	**SWS** 5

Module name TK1: Distributed Systems and Algorithms					
Module Nr. 20-00-0065	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language English			**Module owner** Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		

1	**Content** Objectives: - Comprehensive overview about the fundamental problems and approaches in distributed computing - In-depth methodical knowledge about classical distributed algorithms and programming paradigms - Applied knowledge of current developments and standards Course Content: - Introduction - Recap of and addition to the first chapter of the Net Centric Computing lecture - Distributed algorithms - Distributed programming
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with the concepts of distributed algorithms and programming. They understand the fundamental issues of distributed systems and the classical distributed algorithms and programming paradigms. They are able to apply these classical and current standards of distributed programming to given problems.
3	**Recommended prerequisite for participation** Computer Networks and Distributed Systems
4	**Form of examination** Module Eccompanying Examination: • [20-00-0065-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0065-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

Literature recommendations will be updated regularly, an example might be:
- George Coulouris, Jean Dollimore, Tim Kindberg: Distributed Systems. Concepts and Design (Gebundene Ausgabe) 832 Seiten, Addison Wesley; Auflage: 4th (14. Juni 2005), ISBN: 0321263545
- M. Boger: Java in verteilten Systemen, 1999, dpunkt-Verlag, Heidelberg, ISBN: 3932588320
- G. Tel: Introduction to Distributed Algorithms, 2nd Ed 2001, Cambridge University Press, ISBN: 0521794838
- A. Tanenbaum, M.v.Steen, Verteilte Systeme: Grundlagen und Paradigmen, Pearson Studium 2003, ISBN: 3827370574
- A. Tanenbaum: Computernetzwerke. 4te Auflage. Pearson Studium 2003, ISBN-10: 3827370469
- J. Kurose, K. Ross: Computer Networking, 1. Ed. 2000, Adison-Wesley. ISBN: 0201477114
- L. Peterson, B. Davie, Computernetze, 1. Aufl. 2000, dpunkt Heidelberg, ISBN: 393258869X
- Hammerschall, U.: Verteilte Systeme und Anwendungen. Pearson, München 2005, ISBN: 3827370965

Courses

Course Nr.	**Course name**		
20-00-0065-iv	TK1: Distributed Systems and Algorithms		
Instructor		**Type** Integrated Course	**SWS** 4

Module name TK3: Ubiquitous / Mobile Computing					
Module Nr. 20-00-0120	**Credit Points** 6 CP	**Workload** 180 h	**Self study** 120 h	**Duration** 1	**Cycle offered** Every 2. Sem.
Language German			**Module owner** Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		

1	**Content** Objectives: - Knowledge of technical basics of the mobile communication - Knowledge of important challenges of the Ubiquitous Computing - Methodic knowledge about current approaches to these challenges Course Content: - Introduction to Ubiquitous Computing - Mobile Communication - Internet of Things: RFID and Smart Items - Service Discovery & Cloudlets - Context- and Location-aware Computing - Human Computer Interaction - Privacy and Trust in Ubiquitous Computing
2	**Learning objectives / Learning Outcomes** After successfully attending the course, students are familiar with the technical basis of mobile communication. They understand the fundamental challenge of ubiquitous computing. They know current approaches to solve these challenges. They are able to apply their knowledge to build ubiquitous computing systems.
3	**Recommended prerequisite for participation** Computer Netzwerke and Distributed Systems
4	**Form of examination** Module Eccompanying Examination: • [20-00-0120-iv] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0120-iv] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)** In dieser Vorlesung findet eine Anrechnung von vorlesungsbegleitenden Leistungen statt, die lt. §25 (2) der 5. Novelle der APB und den vom FB 20 am 30.3.2017 beschlossenen Anrechnungsregeln zu einer Notenverbesserung um bis zu 1.0 führen kann.
8	**References**

Literature recommendations will be updated regularly, an example might be:
A Primary Literature:
Handbook of Research: Ubiquitous Computing Technology for Real Time Enterprises edited by Prof. Dr. Max Mühlhäuser, Dr. Iryna Gurevych, 2008, Information Science Reference, ISBN-10: 1599048329
B Secondary Literature:
1. F. Adelstein, S. Gupta et al.: Fundamentals of Mobile & Pervasive Computing McGraw Hill 2004,
2. Stefan Poslad: Ubiquitous Computing, Wiley 2009, ISBN 978-0-470-03560-3
3. Kapitel Mobilkommunikation: M. Sauter: Grundkurs Mobile Kommunikationssysteme: UMTS, HSDPA und LTE, GSM, GPRS und Wireless LAN; Vieweg-Teubner Studium 2010
4. J. Krumm (Ed.): Ubiquitous Computing Fundamentals, CRC Press 2010
D. Cook, S. Das (Ed.): Smart Environments, Wiley 2005

Courses

Course Nr.	**Course name**		
20-00-0120-iv	TK3: Ubiquitous / Mobile Computing		
Instructor		**Type** Integrated Course	**SWS** 4

Module name					
Ubiquitous computing in business processes					
Module Nr.	**Credit Points**	**Workload**	**Self study**	**Duration**	**Cycle offered**
20-00-0121	3 CP	90 h	60 h	1	Every 2. Sem.
Language			**Module owner**		
German and English			Prof. Dr. rer. nat. Eberhard Max Mühlhäuser		

1	**Content** - Learning how state-of-the-art ubiquitous computing technologies can be utilized in enterprise business processes and in the context of smart city services - Identifying technologies' economic potential for business processes and in the context of smart cities - Understanding underlying technologies, their benefits, challenges, and corresponding business cases - Technologies considered will be RFID technology and its integration with business processes, other smart items (e.g., smart shelfs), etc. - Demonstration of how integration works between the real world and the virtual world as it is represented in enterprise software systems today - Hands-on experience and live demonstrations
2	**Learning objectives / Learning Outcomes** After participation in this course, students will have aquired knowledge about implications of ubiquitous computing on business to business processes and in the context of smart city services in conjunction with basic concepts.
3	**Recommended prerequisite for participation**
4	**Form of examination** Module Eccompanying Examination: • [20-00-0121-vl] (Technical Examination, Written/Oral Examination, Standard BWS)
5	**Grading** Module Eccompanying Examination: • [20-00-0121-vl] (Technical Examination, Written/Oral Examination, Weighting: 100 %)
6	**Usability of this module** B.Sc. Informatik M.Sc. Informatik M.Sc. Wirtschaftsinformatik B.Sc. Psychologie in IT Joint B.A. Informatik B.Sc. Sportwissenschaft und Informatik M.Sc. Sportwissenschaft und Informatik May be used in other degree programs.
7	**Grade bonus compliant to §25 (2)**
8	**References** - Mühlhäuser, M.; Gurevych, I. (Eds.): Ubiquitous Computing Technology for Real Time Enterprises Information Science Reference, Dezember, 2007 - Finkenzeller, K: RFID-Handbuch. Grundlagen und praktische Anwendungen von Transpondern, kontaktlosen Chipkarten und NFC. Hanser Fachbuch; Auflage: 5., aktual. u. erw. Aufl. (1. Oktober 2008) - Fleisch, E.; Mattern, F. (Hrsg.): Das Internet der Dinge: Ubiquitous Computing und RFID in der Praxis, Springer, Berlin, Heidelberg, New York 2005 - Österle, H.; Fleisch, E.; Alt, R.: Business Networking – Shaping Collaboration between Enterprises, Springer - Callaway, E.H.: Wireless Sensor Networks: Architectures and Protocols, Auerbach Publications

Courses

	Course Nr.	Course name		
	20-00-0121-vl	Ubiquitous computing in business processes		
	Instructor		**Type**	**SWS**
			Lecture	2