THE OTTO-FRIEDRICH UNIVERSITY OF BAMBERG

FACULTY OF INFORMATION SYSTEMS AND APPLIED COMPUTER SCIENCES (WIAI)

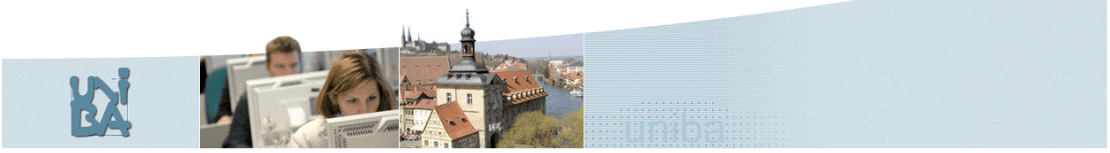
MODULE HANDBOOK

Undergraduate and Graduate Studies in

INFORMATION SYSTEMS AND APPLIED COMPUTER SCIENCES

Academic Year 2008-2009

www.uni-bamberg.de/wiai



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Contents

1 INTRODUCTION AND GENERAL INFORMATION

This document lists all modules offered in the Faculty of Information Systems and Applied Computer Sciences during the academic year 2008-2009.

To prevent problems arising from late changes on these offerings, you are advised to confirm module specifications and schedules through the research groups' web pages or directly with the responsible teaching staff. There may also be new courses becoming available on short notice. Please see the faculty's web pages for relevant announcements. The German module handbook can be found at

- http://www.uni-bamberg.de/wiai/leistungen/studium/modulhandbuch/

Fees and Registration

All modules are currently open free of charge to foreign guest students who will study at Bamberg University within the frame of a partnership exchange programme, such as ERASMUS/LLP. There are no tuition or bench fees. Enrolment with the University may incur a nominal registration fee covering administration charges, student union membership (Studentenwerk) and Bamberg travel ticket.

Information on the registration and enrolment process may be obtained from the Academic Exchange Office (*Akademisches Auslandsamt*, see address below) who will also be able to advise you on any exchange scheme that may exist between Bamberg University and your home institution.

Once admitted to and enrolled with Bamberg University you do not need to register for attending a teaching module. Feel free to sit in and participate in any course offering that fits your educational needs and time table. Be aware, though, that some courses may have entry requirements.

Teaching Times

The academic year 2008-2009 consists of two teaching periods:

- Winter Semester: 13 October 2008 - 07 February 2009
- Summer Semester: 20 April 2009 – 25 July 2009.

Assessment

The course assessment is done mostly by written exams and optionally also by way of homework assignments or lab practicals. In some cases the final exam is oral. Modules specifying "…and *part of final oral examination*" offer both written and oral exams in line with the regulations of our local Diploma degrees.

Final written exams are usually held immediately after the end of the semester, i.e. February/March for the Winter Semester and end of July/August for the Summer Semester. Be aware that there are firm deadlines for exam registration some time during the second half of the semester. If you miss the online registration deadline set by our FlexNow! system make sure register with the course lecturer directly. Also, if for some reason you cannot attend the regular exam, say because you are returning home early, talk to the course lecturer. They may be able to arrange an oral exam for you at an earlier date instead.

The official exam language is German, but many courses may offer written exams in English if required. Some modules may even be taught in English, at the discretion of the lecturer. If you need to be set an English exam you should contact the module lecturer early to find out if this is possible.

Workload

The module descriptions below specify the total module workload in terms of ECTS (European Credit Transfer System) credit points according to the following approximate accounting scheme:

- 1 ECTS = 30 hrs total student workload (all inclusive)
- 30 ECTS = total module load per semester
- 6 ECTS = single standard course module of 4 hrs/week combining lectures+tutorials

Course Levels and Teaching Format

In line with our traditional Diploma degree programmes, modules are taught at 2 major levels:

- Basic Studies

  These are foundational and introductory courses in the general disciplines of Information Systems and Applied Computer Sciences corresponding to the 1st and 2nd year of the undergraduate BSc programme.

- Advanced Studies

  These are introductory courses to specialised fields within Information Systems and Applied Computer Sciences corresponding to the 3rd and 4th year of the BSc degree and advanced modules in particular research areas which correspond to the 1st and 2nd year of the graduate MSc programme.

Most modules are based on combined lectures and tutorials. Some courses may also involve lab classes, excursions, blended learning and other teaching arrangements. Research groups regularly offer advanced level seminars on varying research topics. These may have special entry prerequisites.

Other Information

The Academic Exchange Office provides assistance on accommodation, living expenses, language courses and many other aspects of student life at Bamberg. You are welcome to contact the International Liaison Officer of the WIAI Faculty.

Academic Exchange Office (*Akademisches Auslandsamt*)

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2 MODULE DESCRIPTIONS

2.1 Summary

The following table summarises all modules scheduled to run during 2008-2009. It is expected that most of these courses, which are fixed elements of our Diploma, BSc and MSc programmes, will continue to be offered in 2009-2010 as well.

WS = Winter Semester, SS = Summer Semester

Basic Studies	ECTS credits	offering	Page ref
Development and Operation of Application Systems	6	SS	10
Electronic Business	6	WS	11
Multimedia Technology	6	WS	14
Discrete Foundations	6	WS	21
Machines and Languages	6	SS	22
Introduction to Computing for Students from the Humanities	6	WS	26
Foundations of Business Information Systems	6	WS	32

Data Management Systems	6	SS	32
E-Finance	8	SS	35
IT-Controlling	8	WS	36
Basics of Information Technology: Introduction to Computer Science	6	WS	39
Basics of Information Technology: Practical Introduction into Java	3	WS	40
Basics of Information Technology: Computer-Architecture/Operating Systems	6	WS	41
Basics of Information Technology: Software Development Techniques	3	SS	42
Basics of Information Technology: Software Techniques Laboratory	6	SS	42

Advanced Studies	ECTS credits	offering	Page ref
Enterprise Resource Planning Systems	6	WS	11
Electronic Commerce Systems	6	SS	11
Management Support Systems	6	WS	12
Seminar in Industrial Application Systems	6	SS	12
Information and Knowledge Management	6	WS	13
Information Retrieval 1	6	WS	15
Information Retrieval 2	6	SS	15
Web Engineering	6	SS	16
Computer Graphics and Animation	6	SS	17
Seminar Media Informatics	3	WS/SS	17
Data Communication	6	SS	18
Multimedia-communication in high-speed networks	6	SS	18
Mobile communication networks and mobile computing	6	WS	19
Modelling and analysis of communication networks and distributed systems	6	WS	19
Seminar Communication Systems	6	WS/SS	19

2.2 Industrial Application Systems

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Basic Studies (1st and 2nd year)

Development and Operation of Application Systems (IAWS-EBAS-B)

Entwicklung und Betrieb von Anwendungssystemen

Application systems are actors of automated business tasks. Depending on their fields of application they occur in different forms and specifications. The module provides architectural features of application systems as well as methodologies for the development and operation of these systems. The architectural features cover the integration of applications and its distribution on appropriate resources. We will describe the methodologies on the basis of a project model with the partial models 'system engineering', 'project management', 'quality assurance' and 'configuration management'. We will present suitable software development environments for the implementation of the project model. In the accompanying tutorial you will learn to develop sample application systems and you will get to know components of software development environments.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

Electronic Business (IAWS-E-Biz-B)

E-Business

The module covers different architectures of industrial and service enterprises. Main areas are the objectives and strategies of enterprises, their business processes, and the supporting application systems. We treat Enterprise Resource Planning Systems and Management Support Systems within enterprises. The relationships among enterprises and between enterprises and private households are the subject of Electronic Commerce Systems.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

Advanced Studies (3rd and 4th year)

Enterprise Resource Planning Systems (IAWS-ERP-M)

Enterprise-Resource-Planning-Systeme

The module consists of three main parts. The first part, production and operations management, deals with the design of industrial enterprises, especially with models of computerized manufacturing systems and material flow systems as well as concepts for control of such systems (CAx). The second part covers the two topics application systems in general and modeling of business processes and application systems serving as a basis for the next part which deals with the control of industrial enterprises. We take a close look at the functions production planning and control, materials management, maintenance and sales & distribution as well as the supporting applications systems. In the accompanying tutorial in addition we present selected simulation processes as well as methods for production planning and control. An ERP-system is used for practical application.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

Electronic Commerce Systems (IAWS-E-COM-M)

E-Commerce-Systeme

This module focuses on business models in electronic commerce and inter-organizational business processes. Especially the concepts of Supply Chain

Management and Customer Relationship Management are covered in detail, Electronic commerce services, the economy of the internet as well as architectures of application systems and IT-technologies within these functional areas are further topics.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

Management Support Systems (IAWS-MSS-M)

Management-Support-Systeme

Management Support Systems (MUS) in general are used to support decision making in various problem fields. The module deals especially with the analysis of complex and weak structured problems and the investigation of the support of decision processes by application systems (e. g. Business Intelligence Systems). The tutorial provides the simulation of decision situations through several scenarios using models in combination with commercially available management support systems.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minutes written examination

Seminar

The seminar in Industrial Application Systems is a combination of three kinds of academic work: homework, presentation, and discussion. The topics of the seminar cover the entire range of information systems especially industrial application systems. The different topics of the seminar are published at the beginning of the semester.

Hours per Week / Semester: 2 / summer	**Teaching Method:** Seminar
Credits: 3	**Examination:** Essay (25 pages), presentation, continuous assessment

Information and Knowledge Management (IAWS-IWM-B)

Informations- und Wissensmanagement

Business information systems can be interpreted as the nervous system of an enterprise in analogy to the nervous system of an organism. The information management of an enterprise has the function to specify, to build and to operate the business information system according to the business objectives. Knowledge management completes the information management in management of human knowledge and the computer supported representation and processing of knowledge. This module deals with tasks and methods of information management as well as knowledge management and derives necessary characteristics of the appropriate resources from them.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minutes written examination

2.3 Media Informatics

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General Information: All exams (basic and advanced) may be taken in English. Lectures and tutorials are offered in German.

Basic Studies (1st and 2nd year)

Multimedia Technology (MI-MMT-B)

Multimedia-Technik

This course deals with media and media formats. Among that are XML for structured text, SVG and VRML for 2D- and 3D-graphics and animation, JPEG, GIF and, TIFF for images, PCM, MP3, MIDI for audio, as well as MPEG for video. Besides the formats the corresponding fundamentals are examined, like colour- and perception-models, aspects of quality-of-service and engineering-like development of multimedia systems. The intention is to teach practical skills with the mentioned formats and with the development of concepts for coding- and compression-techniques. For this, the course, which generally wants to give a broad overview of the domain, looks at selected topics in more detail. Examples for this are VRML, JPEG and MP3.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written examination

Advanced Studies (3rd and 4th year)

Information Retrieval 1 (MI-IR1-M)

Information Retrieval 1 – Grundlagen, Modelle und Anwendungen

Information Retrieval (IR) addresses the search for documents. Traditionally these are textual documents. Today the search for multimedia documents, e.g. images, audio, video as well as hypertext documents is getting more and more important. Furthermore with the proliferation of the World Wide Web Information Retrieval gains even more prominence and actuality.
Within this course we cover essential information retrieval models and algorithms as well as the evaluation of information retrieval systems:

- Motivation and Introduction
- Evaluation of IR Systems
- Considering the Vagueness of Natural Languages
- Pattern Matching within Text – Simple Models and Algorithms
- Simple IR Models and their Implementation (Boolean Retrieval, Coordination Level Match, …)
- Vector Space Model
- Formats for Structured Documents and Knowledge Representation
- Alternatives to Searching – Classification, Clustering and Browsing
- Multimedia Information Retrieval

Prerequisites: Multimedia Technology, Programming skills (in particular, object-oriented)

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written examination

Information Retrieval 2 (MI-IR2-M)

Information Retrieval 2 – ausgewählte weiterführende Themen

Within this course we build upon the fundamentals addressed within Information Retrieval 1. We consider advanced information retrieval models as well as advanced algorithms and data structures used for searching images and structured documents. Furthermore we focus on commercial data base systems and their support for information retrieval. Finally we address internet search engines. The topics are:

- Advanced Concepts for the Evaluation of Information Retrieval Systems
- Pattern Matching within Text – Advanced Models and Algorithms
- Probabilistic Information Retrieval

- Advanced Information Retrieval Models – LSI, Bayesian Networks, …
- Multimedia Information Retrieval – Index Structures and Search Algorithms
- Support for Information Retrieval within Commercial Data Base Systems
- Information Retrieval and the Internet – Fundamentals and Architecture of Search Engines
- Information Retrieval and the Internet – Stating Queries and Query Processing

Prerequisites: Multimedia Technology, Information Retrieval 1, programming skills (in particular, object-oriented)

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written examination

Web Engineering (MI-WebE-B)

Web Engineering

Web-enabled applications provide ubiquitous access to information systems. In practice, ad-hoc approaches dominate the development process of web applications while software engineering methods as known from application development are lacking. The module Web Engineering gives a practical introduction into methods that may be applied to solve these difficulties. Web Engineering builds upon the conclusions of Software Engineering and covers the whole life-cycle of web applications.
The module addresses various activities of Web Engineering, including requirements engineering, modelling, architectural and design stages, implementation techniques, testing, operation, and maintenance.
We will present current concepts, methods, techniques, and tools for the different activities in Web Engineering. One of the key learning objectives is practical competencies in web application development which will be achieved in a Java-based development environment.

Prerequisites: Multimedia Technology, programming skills (in particular, object-oriented)

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written examination

Computer Graphics and Animation (MI-CGuA-M)

Computergrafik und Animation

This course deals with all important aspects of three-dimensional computer graphics and covers the basic mathematic principles as well as the implementation in tools for animation development. That provides a basis for a specific use of these tools for creating animations and virtual worlds.
The topics of this course are similar to the standard work from Watt: basic mathematic principles of computer graphic, description and modelling of three-dimensional objects, display and rendering, the graphics-pipeline, reflection models, illumination, the radiosity method, ray tracing techniques, volume rendering, colours in computer graphics, image-based rendering and photo-modelling, computer animation.

Prerequisites: Multimedia Technology, programming skills (in particular, object-oriented)

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written examination

Seminar Media Informatics (MI-Sem-B)

Bachelor-Seminar zur Medieninformatik

Seminars are offered irregularly on varying topics in Media Informatics, both in the winter and/or summer semesters. The seminars are usually advertised at the beginning of each semester.

Hours per Week / Semester: 2 / winter, summer	**Teaching Method:** Seminar
Credits: 3	**Examination:** Essay, presentation, continuous assessment

Research Projects in Media Informatics (MI-Prakt-M)

Praktikum zur Medieninformatik

Advanced students interested in pursuing a research project leading to a thesis at undergraduate (bachelor) or graduate (masters, doctoral) level are invited to contact the Media Informatics Group for proposals. Possible topics would typically fall within the fields of information retrieval or visualization. Some selected proposals can be found on the group's web pages. Depending on the candidate's preferences and background the project might focus more on theory or implementation.

2.4 Communication Systems and Computer Networks

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Advanced Studies (3rd and 4th year)

Data Communication (KTR-Datkom-B)

Datenkommunikation

Introduction to communication networks, layered architectures, OSI protocol reference model, TCP/IP suite, digital transmission fundamentals, peer-to-peer protocols and data link layer, medium access control protocols, local area networks, ISDN.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures (2) and Tutorials (2)
Credits: 6	**Examination**: 90 minute written examination

Multimedia-communication in high-speed networks (KTR-MMK-M)

Multimedia-Kommunikation in Hochgeschwindigkeitsnetzen

Fundamentals of data networking, evolution of communication services, multimedia communication and services (HTTP, Video-Streaming, H.323, VoIP), TCP/IP architecture, circuit- and packet-switched networking, network architecture of BISDN, ATM networks, traffic management, IP networks with QoS mechanisms (Diffserv, Intserv, MPLS).

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures (3) and Tutorials (1)
Credits: 6	**Examination:** 90 minute written examination

Mobile communication networks and mobile computing (KTR-Mobi_m)

Mobilkommunikation und Mobile Computing

Development of mobile networks and services, fundamentals of wireless tranmission, medium access control protocols, data link layer protocols, network layer protocols and mobility management, mobile IP, TCP in wireless environments, wireless local area networks (IEEE.802.11, Hiperlan), wide area mobile networks (GSM, GPRS, UMTS).

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures (3) and Tutorials (1)
Credits: 6	**Examination:** oral examination

Modelling and analysis of communication networks and distributed systems (KTR-MAKV-M)

Modellierung und Analyse von Kommunikationsnetzen und Verteilten Systemen

Modeling of distributed systems, probability theory and statistics, stochastic processes: Poisson and renewal processes, Markov chains; numerical solution methods for Markov chains, elementary Markovian queueuíng models, loss networks, elementary queueing networks.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures (3) and Tutorials (1)
Credits: 6	**Examination:** 90 minute written examination

Seminar (KTR-Sem-M)

Hauptseminar

Seminars are regularly offered on varying topics of computer networking. They comprise a combination of homework, presentation, and discussion. The upcoming topics of the seminars are announced at the end of the semester.

Hours per Week / Semester: 2 / winter or summer	**Teaching Method:** Seminar
Credits: 6	**Examination:** Essay, final presentation, continuous assessment

Advanced Laboratory (KTR-GIK-M)

Grundbausteine der Internet-Kommunikation

Advanced laboratories are regularly offered on varying topics of computer networking. They comprise a combination of assignments, project tasks, presentations, and discussion. The upcoming topics of the laboratory are announced at the beginning of the semester.

Hours per Week / Semester: 4 / winter or summer	**Teaching Method:** Seminar
Credits: 6	**Examination:** Deliverables, presentations, continuous assessment, final oral examination

2.5 Foundations of Computer Science

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General Information:

- The content of the courses may be adjusted in line with research interests, new requirements of the curriculum or background of students, possible even on short notice. Although we try to keep the course descriptions up to date, the material presented in the classes in a particular semester may differ slightly from what is given below.
- All courses, except seminars and research projects unless otherwise specified, are assessed by written question papers presented during the examination period at the end of each semester. Guest students who are staying at Bamberg for just one examination period (i.e. one semester) may contact the course lecturer for special arrangements on resit exams.
- All exams (basic and advanced) may be taken in English. Lectures and tutorials may be offered in English, too, if required. Please contact the course lecturer.

Basic Studies (1st and 2nd year)

Discrete Foundations (GdI-MfI-B)

Mathematik für Informatiker

This module covers key elements in discrete mathematics (set theory, logic and algebra) relevant to Computer Science and Business Informatics. At the end of this course students should be able to perform elementary calculations

in algebraic structures such as Boolean, functional and relational algebras; be familiar with basic combinatorial and logical principles (such as Russell's Paradox, diagonalisation and the existence of uncountable sets, Pigeon-Hole Principle, counting, fixed-point theorems, recursion and induction); know basic techniques such as formal power series for solving recurrence equations; be familiar with the concept of a formal system and formal calculus and have understood the fundamental difference between syntax and semantics, soundness and completeness; be able to formalize real-world concepts in propositional and predicate logic and have developed skills in reasoning using formal calculi for these logics; be able to apply elementary proof principles (proof by contraposition, proof by cases, natural and structural induction).

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures, Tutorials, Practice Labs
Credits: 6	**Examination:** 90 minute written paper; oral resit possible

Machines and Languages (GdI-GTI-B)

Grundlagen der Theoretischen Informatik

This course addresses the questions "what is a computation?" and "what is an algorithm?" and explores the capabilities and limitations of computers and programming languages as well as the implication of these for a practical computer scientist. It introduces the basic concepts and methods that underlie the mathematical study of computing machines and formal languages. At the end of this course the students should be able to distinguish finite automata, pushdown automata, Turing machines, and know the difference between the deterministic and non-deterministic versions in each case; be able to distinguish regular, context-free, context-sensitive and general phrase structure grammars in the Chomsky Hierarchy; understand the relations between language classes and machine classes; have developed elementary automata and Turing machine programming skills; know the basic concepts of algorithmic complexity theory such as the big-O notation, complexity classes N and NP.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written paper, oral resit possible

Advanced Studies (3rd and 4th year)

Programming Language Semantics (GdI-NPP-B)

Nichtprozedurale Programmierung

The aim of this module is to provide a deeper understanding of programming languages, their semantics and applications. This course focuses on the operational semantics of functional and logical programming, and stresses the importance of the concept of types and type checking. At the end of this course students should be familiar with the computational principles behind functional and logical programming, as well as their relationship; be familiar with important language constructs and their semantics (e.g., expressions, local declarations, function and relational abstraction, recursion, lazy and eager evaluation, unification, backchaining); have an appreciation of the major techniques and underlying principles of the formal specification of semantics (axiomatic, denotational, operational) and extended skills in using structural operational rules; have understood the concept of inductive rule systems and their relevance to the specification of complex systems; have an appreciation of the close relationship between programming language types and specification, and the role of type checking as a formal verification method; be familiar with polymorphic Hindley-Milner style type systems.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures, Tutorials, Practice Labs
Credits: 6	**Examination:** 90 minute written paper, oral resit possible

Specification and Verification (GdI-SaV-B)

Logik

This advanced module aims to give a thorough introduction to a selection of logics with strong applications in Computer Science. Basic knowledge of classical propositional logic and predicate logic and associated calculi is assumed as a prerequisite. Among the logics covered are intuitionistic logic, modal and temporal logics for the analysis of distributed systems. Depending on the time available, the module also covers belief logics and other specialised logics for security protocols and distributed algorithms. The course addresses theoretical foundations (models and proofs) but also discusses applications and offers practical experience through hands-on experimentation with automatic and interactive verification tools.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 90 minute written paper, oral resit possible

Communication and Concurrency (GdI-CaC-M)

Theorie Verteilter Systeme

This advanced course gives an introduction to the algorithmic and semantic foundations in the programming of distributed systems and discusses state-of-the-art techniques in the formal modelling and validation of distributed systems. At the end of this course the students should be familiar with elementary algorithms, specifically for resource synchronization, mutual exclusion, leader election, Byzantine agreement, global time-keeping; be able to reason about and argue for the correctness of these algorithms; understand the elementary trade-offs governing the algorithms' time and communication complexities; have a clear appreciation of the intricacies arising from the task of solving global synchronisation problems by local (asynchronous) means of communication; know some of the central impossibility results; be familiar with different behavioural models for distributed systems of varying expressiveness, such as Petri Nets, Kripke structures, labelled transition systems, hybrid automata; understand the operational principles of modern (visual) programming languages for globally-synchronous and locally-asynchronous systems such as Statecharts or Esterel.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 20 minutes oral examination

Information Security (GdI-IaS-M)

Informationssicherheit

Commercial as well as private and public businesses increasingly exploit the world wide web as an efficient and innovative communication platform. Since the web is openly accessible, widely distributed and largely uncontrolled ("best-effort" principle) the dangers of information security violation are real and bound to cause considerable headaches in the future. This course gives an introduction to the problem and surveys state-of-the-art cryptographic methods and standardised security mechanisms based on them that are designed to counter the risks and to establish secure communication through unsafe channels. It will be discussed how properties such as confidentiality, authentication, data integrity, anonymity, commitment can be achieved systematically through security protocols. At the end of this course students should be familiar with most important modern techniques for encryption and decryption; know some of the prominent historic ciphers; have acquired the necessary elementary background in number and coding theory; understand the difference between symmetric and asymmetric encryption; have understood the RSA cryptographic system and possible attacks on it; be familiar with mathematical technology such as one-way functions and hard-core predicates to amplify secrecy and to turn a cryptographic system such as RSA into practical use; be able to appreciate the difference between perfect

information-theoretic secrecy and computational secrecy; be able to compute the information-theoretic secrecy of simple encryption systems; be familiar with BAN logic and able to perform logical analyses of elementary security protocols using BAN or one of its successors.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures and Tutorials
Credits: 6	**Examination:** 20 minutes oral examination

GdI Seminar

Seminars are offered irregularly on varying topics in the Foundations of Computer Science, Advanced Software Engineering and Formal Methods, both in the winter and/or summer semesters. The seminars are usually advertised at the beginning of each semester. Seminars will be held in English if needed.

Hours per Week / Semester: 2 / winter, summer	**Teaching Method:** Seminar
Credits: 3	**Examination:** Essay, presentation, continuous assessment

Research Projects in Foundations of Computer Science

Advanced students interested in pursuing a research project leading to a thesis at undergraduate (bachelor) or graduate (masters, doctoral) level are invited to contact the Theory Group for proposals. Possible topics would typically fall within the theory and application of logics, type theory, process algebra and the semantics of visual programming languages. Some selected proposals can be found on the group's web pages. Depending on the candidate's preferences and background the project might focus on theory or implementation.

2.6 Applied Computer Science

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Basic Studies (1st and 2nd year)

Introduction to Computing for Students from the Humanities

(Modul KInf-InfKult-E) *Informatik für die Kulturwissenschaften*

(Modul KInf-ProgKult-E) *Programmierkurs für die Kulturwissenschaften*

First course in Computing Science not requiring previous experience with computers. Introduction into basic concepts: Information, data, knowledge; architecture of computer systems; principles of programming: control and data structures, software engineering process; computer applications: geographic information systems and digital libraries; theory of computing: fundamental limitations and how to cope with them in practice; future trends of computing: semantic information processing. Exercises include text problems and programming tasks.

Prerequisites: none

Hours per Week / Semester: 6 hours per week, winter	**Teaching Method:** Lecture, exercise and tutorial Lessons
Credits: 9	**Examination:** Written final exam, assignments

Advanced Studies (3rd - 5th year)

Semantic Information Processing (KInf-SemInf-M)

Semantische Informationsverarbeitung

Computational methods and tools for semantic information processing with special focus on knowledge-based approaches. Topics covered include: problem solving by heuristic search, constraint solving, representation and reasoning with domain-specific knowledge, formal ontologies, machine learning and knowledge discovery, neural networks.

The design of intelligent agents and agent systems is adopted as unifying perspective for presenting the material. Examples from GIS applications or digital libraries illustrate how the methods from semantic information processing blend with more traditional approaches to software design. Programming exercises in Java complement the lecture.

Prerequisites: Algorithms and Datastructures, Machines and Languages

Hours per Week / Semester: 4 hours per week, winter	**Teaching Method:** Lecture and exercise Lessons
Credits: 6	**Examination:** Written final exam

Geographic Information Systems (KInf-GeoInf-B)

Modul KInf-GeoInf-B: Geoinformationssysteme

This lecture introduces into fundamntal concepts of geographic information processing. Topics covered include: representation of spatial objects, digital maps, acquisition of geographic data, visualization and analysis of spatial data, spatial indexing (e.g. R-trees), spatial query processing and spatial SQL. Connections to semantic information processing, especially those arising from interoperability issues, are established. Possible fields of application for GIS are illustrated with special emphasis on current trends in mobile computing.

Prerequisites: Discrete foundations, Algorithms and data structures

Hours per Week / Semester: 4 hours per week, summer	**Teaching Method:** Lecture and exercise Lessons
Credits: 6	**Examination:** Written final exam

Mobile Assistance Systems (KInf-MobAss-M)

Modul KInf-MobAss-M: Mobile Assistenzsysteme

A digital travel guide running on a smart phone and a CAD-based system for the documentation of built heritage with a TabletPC are two examples of software solutions designed to assist mobile users, that is, examples of mobile assistance systems.

The objective of the course is to introduce students to the research literature on mobile assistance systems and to enable them to put the acquired concepts and methods into practice. Half of the material is covered in reading sessions and half in lab sessions. The course is teached in English.

Prerequisites: Programming course, Machines and languages

Hours per Week / Semester: 4 hours per week, summer	**Teaching Method:** Reading sessions and lab sessions
Credits: 6	**Examination:** Written final exam, assignments, colloquium

2.7 Cognitive Systems

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General Information: All exams may be taken in English. Lecture slides are in English. Lectures and tutorials may be offered in English, too, if required.

Advanced Studies (3rd - 5th year)

Intelligent Agents (KogSys-IA-B)

Intelligente Agenten

In this course basic concepts and methods of cognitive oriented artificial intelligence are introduced in the context of problem solving and action planning. Core topics are: STRIPS planning, logic and deductive planning, heuristic search and heuristic planning, planning graph techniques, SAT-planning, and multi-agent planning. Throughout the course, relations to human problem solving and planning are discussed. In the practice part methods and techniques are applied and partially implemented in Prolog. The course language is German, slides and reading materials are in English.

Prerequisites: Basic programming knowledge (for solving the practicals), basic knowledge in algorithms (search algorithms) and logic.

Hours per Week / Semester: 4/summer	**Teaching Method:** Lectures and tutorials, assignments
Credits: 6	**Examination:** 90 minutes written examination

Machine Learning (KogSys-ML-M)

Lernende Systeme

In this master-level course well-known symbolical, statistical, and neuronal approaches to machine learning are introduced and relations to human learning are discussed. Core topics are: decision tree algorithms, multi-layer perceptrons, instance-based learning, genetic algorithms, inductive logic programming, Bayesian learning, computational learning theory, inductive program synthesis, and reinforcement learning. In the practice part, some methods and techniques are applied and implemented in Java and Prolog. The course language is German, slides and reading materials are in English.

Prerequisites: Basic programming knowledge (for solving the practicals), basic knowledge in algorithms (search algorithms) and logic.

Hours per Week / Semester: 4/winter	**Teaching Method:** Lectures and tutorials, assignments
Credits: 6	**Examination:** 90 minutes written examination

Human Computer Interaction (KogSys-HCI-M)

Mensch-Computer Interaktion

In this course basic concepts of cognitive psychology and artificial intelligence are introduced with respect to design and evaluation of interactive computer systems. Furthermore, core principles and methods of empirical research are introduced which can be applied for usability studies and software evaluation. Core topics are: Basic concepts of the psychology of perception and of thinking, empirical research methods, cognitive architectures. Advanced topics introduced in the last part of the lecture are, for example: user adaptivity, enduser programming, and intelligent tutor systems. In the practice part, a small usability study will be conducted.

Prerequisites: Successful participation KogSys-IA-B.
Remark: KogSys-IA-B can be replaced by some other course where basic methods and approaches of artificial intelligence were introduced.

Hours per Week / Semester: 4/winter	**Teaching Method:** Lectures and tutorials, assignments
Credits: 6	**Examination:** 20 minutes oral examination

Practical Cognitive Systems (KogSys-Prak-M)

Praktikum Kognitive Systeme

In this course, offered on bachelor and master level, design and analysis of cognitive systems are practiced in small teams. The topics are derived from current research work in the cognitive system group. A practice course is essential as preparation for thesis work. Participation involves: Acquainting oneself with a topic by searching and evaluating the relevant research papers, discuss the planned project work in context with the state of the art in the field and give an oral presentation; structure the work in form of a requirement specification; fulfilling the specified requirements by designing and/or implementing algorithms, performing theoretical analyses and/or an empirical evaluation of algorithms together with a written report (in form of a scientific paper) and an oral presentation of the results.

Hours per Week / Semester: 4/winter, summer	**Teaching Method:** Seminar, programming lab
Credits: 6	**Examination:** written report and oral presentation

Seminar in Cognitive Systems

Seminar Kognitive Systeme

Seminars are offered bachelor (winter term) and master level (summer term) on varying topics in Cognitive Systems. The seminars are usually advertised at the beginning of each semester.

Hours per Week / Semester: 2 / winter, summer	**Teaching Method:** Seminar
Credits: 6	**Examination:** Essay, presentation, continuous assessment

2.8 Systems Engineering

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Basic Studies (1st and 2nd year)

Foundations of Business Information Systems (SEDA-GbIS-B)

Grundlagen betrieblicher Informationssysteme

Comprehensive introduction to concepts, models, and techniques for the analysis and the design of business information systems. Subjects are systems theory, models of business systems, business functions, and modeling of business information systems.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination**: 90 minute written examination

Data Management Systems (SEDA-DMS-B)

Datenmanagementsysteme

Comprehensive introduction to data management and data management systems. Relational database model, SQL, architecture of data management systems, design of database schemas, case study (development of a data management system), transactions and transaction management, operating of data management systems.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination**: 90 minute written examination

Advanced Studies (3rd and 4th year)

Modelling of Business Information Systems (SEDA-MobIS-B)

Modellierung betrieblicher Informationssysteme

Introduction to methodological concepts of business information systems modelling; investigation of classical and advanced approaches to information systems modelling (data modelling, business process modelling, object-oriented modelling).

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination**: 90 minute written examination

Systems Engineering (SEDA-EbIS-2-M)

Systementwicklung

Systems engineering; software engineering of business application systems; generic architectural framework; domain-specific layer; software layer; layer of programming platforms; control of large systems engineering projects by means of process models; different kinds of process models and their applicability.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

Architectures of database management systems and database application systems (SEDA-EbIS-3-M)

Architekturen von Datenbanksystemen und von datenbankbasierten Anwendungssystemen

Database models; architecture of relational and object-oriented database management systems; transaction models and transaction processing in distributed systems; architectural concepts for improving the data independence of application systems.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

Advanced application systems for Data, Information, and Knowledge Processing (SEDA-EbIS-1-M)

Fortgeschrittene Anwendungssysteme zur Daten-, Informations- und Wissensverbreitung

Data, information, and knowledge; data warehousing; multi-dimensional data model; architecture of data warehouse systems; data mining; knowledge-based application systems; knowledge representation, programming in prolog.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 6	**Examination:** 90 minute written examination

2.9 Information systems in the service industry

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Basic Studies (1st and 2nd year)

E-Finance (ISDL-eFin-B)

E-Finance

E-Finance is the electronic support of financial processes and transactions within and between organizations. This covers (1) secondary financial processes such as cash management and financial chain management, (2) primary processes of the financial services industry such as credit processing, payment transactions, and securities trading, and (3) B2B financial transactions, which are usually fulfilled by products and services of financial service providers via their networks.
Information technology is – next to human resources – the critical production factor in all of these processes. The focus of this module is learning methods that help to shape an efficient and effective IT usage within these processes. Main areas will be: financial chain management, outsourcing of financial business functions, IT compliance in financial service provision, automation and integration of banking processes, and B2B IT infrastructures for securities trading.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 8	**Examination:** 90 minute written examination

IT-Controlling (ISDL-ITCon-B)

IT-Controlling

IT-Controlling is the controlling of a firm's IT resources with the goal of ensuring the efficiency and effectiveness of IT usage, considering quality, function and time. IT-Controlling is not only control and monitoring but rather a comprehensive coordination function (planning, coordination, control) for the overall management of information. The lecture will consist of chapters on (IT) portfolio controlling, project controlling, product controlling, and infrastructure controlling. The strategic and operational instruments to be discussed are IT portfolio management, IT balanced scorecard, IT activity-based costing, total cost of ownership, conception and calculation of business cases, IT key performance indicators, and IT risk management.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 8	**Examination:** 90 minute written examination

Advanced Studies (3rd and 4th year)

Information Systems and Services I – Standards and Networks (ISDL-ISS-1-M)

Informationssysteme in Dienstleistungsbereichen I – Standards und Netzwerke

This module focuses on models and methods covering intra and inter-organizational networks and the necessary standardization of information systems. Technical aspects of internal and external integration of systems, as well as the economic impact of standards for information production and informational services, lead to standardization problems being one of the basic topics in the discipline information systems. The lecture will focus predominantly on the question of how standards can support the automation and inter-organizational integration of processes (i.e. technical aspects of integration; main application domain will be XML and web services), what the strategic problems of standardization are, and how economic and game-theoretical models can be used to solve standardization problems (i.e. economics aspects).

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 8	**Examination:** 90 minute written examination

Information Systems and Services II – Optimization of IT-Reliant Processes (ISDL-ISS-2-M)

Informationssysteme in Dienstleistungsbereichen II – Optimierung IT-lastiger Geschäftsprozesse

This module focuses on approaches to optimizing business processes through efficient IT support. Typical primary and secondary processes of service delivery are examined, objectives and methods for optimization are introduced, and procedure models for optimal process design are discussed. Main application domains will be:

E-Finance: Financial processes can be generally considered as completely digitalizable and appear both as primary processes in the financial services industry and as secondary processes in all other firms. The lecture discusses how optimal IT usage can be attained in the financial service industry, which optimization potentials can be uncovered in the financial chain management of non-banks, and which re-structuring alternatives for the value chain by a “value chain crossing” are practical.

E-HR: The IT support of HR management processes is surprisingly low. Therefore, the status quo and additional possibilities for this typical secondary process will be introduced. Particularly, a (partial) automation of the personnel selection process can be realized by employing recommender systems.

Sourcing: The questions of which IT services are delivered, to where, and by whom, are strategic questions in many scenarios. Advantages and disadvantages, like economies of skill, scale, and scope, will be discussed and decision support models and “best practices”, along with problems and cultural barriers, will be examined.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lecture and Tutorial
Credits: 8	**Examination:** 90 minute written examination

Information Systems and Services III – IT Business Value (ISDL-ISS-3-M)

Informationssysteme in Dienstleistungsbereichen III – IT-Wertschöpfung

This module covers approaches for utilizing the IT resource in order to generate a competitive advantage. Basic IT issues like the IT paradox, IT/IS strategies, IT architecture, and IT governance, IT assets and capabilities in general will be discussed and illustrated by presenting several real world cases. In particular, the services industry applies IT as the primary production resource (aside from human resources), and therefore, the main focus of this lecture will be on how to determine and how to influence the business value contribution of IT.
A main aspect for high effectiveness of IT is the alignment with the requirements of the business process, i.e. the so-called *IT business alignment*. How can the interplay between IT units and non-IT units be put into effect? It will be shown that an effective application of IT will not be primarily a technical question of choosing the right system but rather the consideration of a portfolio which ensures effective usage in the context of the particular

supported business process. Based upon this, key techniques for project management and the valuation of information systems will be introduced. Finally, important aspects of service quality (SERVQUAL) and the new role of the Chief Information Officer (CIO) as a strategic partner and business enabler will be assessed.

Hours per Week / Semester: 4 / summer	**Teaching Method:** Lecture and Tutorial
Credits: 8	**Examination:** 90 minutes written examination

Seminar

The seminar in Information Systems and Services incorporates three kinds of academic work: homework, presentation, and discussion. The topics of the seminar cover the entire range of information systems with a specific focus on industrial application systems. The different topics of the seminar are published at the beginning of the semester.

Hours per Week / Semester: 2 / winter	**Teaching Method:** Seminar
Credits: 6	**Examination:** Essay (12 pages), presentation, continuous assessment

2.10 Practical Computer Science

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Basic Studies (1st and 2nd year)

Basics of Information Technology: Introduction to Computer Science (PI-EidI-B)

Einführung in die Informatik

Objective: To provide students with a basic understanding of and overview about the principles of computer science with an emphasis on algorithmics, programming and software development in an imperative as well as a functional paradigm. Students should be able to apply basic abstraction and representation techniques and should know about the concepts of specification, implementation and correctness as well as syntax and semantics in the context of programming languages.
Contents: The course offers a first introduction in computer science from the programming perspective. The topics discussed include the correspondences between information representation, interpretation and manipulation, syntax and semantics, problem classes and instances, design of algorithms and their implementation via programs, declarative specification vs. algorithmic implementation, abstract data types (stack, queue, list, tree) and their underlying semantics, data abstraction and functional abstraction, stepwise refinement and simple re-use techniques, simple rule-based systems and their processes, Chomsky Typ2 and 3 grammars, finite automata and stack automata. Most of these topics are discussed in the context of the languages SCHEME and Java. Students are required to use the concepts discussed in designing and implementing small programs in both languages.

Literature:

1. Barbara Liskov with John Guttag: Program Development in Java. Addison-Wesley, 2001
2. J. Stanley Warford: Computing Fundamentals. Vieweg, 2002
3. Timothy Budd: An Introduction to Object-Oriented Programming, Pearson/Addison Wesley, 2002 (3rd)
4. Abelson, Sussman: Structure and Interpretation of Computer Programs. MIT Press 1984

Organization: The module is organized in combination with the course *Practical Introduction into Java* that adds the practical programming experience aspects to this course. Partici-pants are assumed to work on assignments (specification and programming) throughout the term.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures (3) and tutorials (1)
Credits: 6	**Examination:** 90 Minutes written examination

Basics of Information Technology: Practical Introduction into Java (PI-Prakt-Java-B)

Java-Einführungspraktikum

Objective: To provide students with a basic understanding of the concepts and techniques required when programming in Java. Students should be able to develop small programs for simple problems on their own using the correct choice of data and control structures as provided by the Java programming language. Students should know and apply the concepts of structuring and abstraction offered in the object-oriented paradigm. Students should be familiar with the different steps involved in developing programs and should be able to use common tools (editor, compiler, documentation, libraries) needed when programming.
Contents: The course is held in combination with the course *Introduction to Computer Science* and provides the practical programming background for that course. It discusses the main concepts of Java as an enabling technology for object-oriented Programming in the Small and introduces to the abstraction and structuring techniques offered by Java like, e.g. interfaces, abstract classes, inheritance and implementation relations, polymorphic typing, packages and visibility rules. Besides discussing the detailed Java-specific aspects, the course puts an emphasis on relating all these concepts to the underlying techniques used in each programming language.
Literature:

1. John Lewis, Joseph Chase: Java Software Structures. Pearson/Addison-Wesley, 2005 (2nd)
2. Bert Bates, Kathy Sierra: Head First Java. O'Reilly, 2005 (2nd)

Organization: The course is held in the last three month of the term after the prerequisites have been discussed in the *Introduction to Computer Science* course. Part of the course is organized as lab studies where all participants are required to attend. Participants are assumed to work on assignments (programming) throughout the term.

Hours per Week / Semester: 2 / winter	**Teaching Method:** Lectures (1) and tutorials (1)
Credits: 3	**Examination:** 90 Minutes written examination

Basics of Information Technology: Computer-Architecture/Operating Systems (PI-RBS-B)

Rechner- und Betriebssysteme

Objective: To provide students with a basic understanding of the principles of modern hardware systems and the relationships between hardware and operating systems issues.
Contents: The course discusses the stepwise development of hardware from basics like Boolean algebra to the implementation of circuits and registers, introduces to the von-Neumann architecture and more advanced modern RISC and CISC computers using parallelism and pipelining, gives an overview of typical assembler languages and their implementation and relates architectural issues to the basic principles of system software (Synchronisation and scheduling of processes and resources, virtual memory techniques, file systems etc.) as used in modern operating systems like Windows and Unix-Derivates.
Literature:

1. Andrew S. Tanenbaum: *Structured Computer Organization*. Prentice Hall, 2006 (5th)
2. Douglas E. Comer: *Essentials of Computer Architecture*. Pearson/Prentice Hall, 2005(1th)
3. Silberschatz, A./Gagne, G./Galvin, P. B.: Operating Systems Concepts. John Wiley and Sons, 2005 (7th)
4. Andrew S. Tanenbaum: *Modern Operating Systems*. Prentice-Hall 2003 (2nd)
5. John L. Hennessy, David A. Patterson: Computer Architecture Morgan Kaufmann, 2002, (3rd)

Organization: Participants are assumed to work on assignments (which includes thread-based programming and synchronisation in Java) throughout the term.

Hours per Week / Semester: 4 / winter	**Teaching Method:** Lectures (3) and tutorials (1)
Credits: 6	**Examination:** 90 Minutes written examination

Basics of Information Technology: Software Development Techniques (PI-SWT-B)

Software Entwicklung

Prerequisites: A basic understanding of and experience in Java programming as well as of implementing simple algorithms (e.g., provided through basic studies).
Objective: Students gain an overview of state-of-the-art approaches to tackle software complexity and an in-depth understanding of the most important paradigms used in the area.
Contents: The course discusses the different approaches to software engineering with a focus on design, implementation and testing. Advanced concepts include architecture-centric approaches to systems and software engineering, Pattern- as well as Component-based software development. The discussion is based on examples from operating systems, middleware and user interface management systems.
Literature:

1. Sommerville, Ian: Software Engineering, 6. Auflage, Pearson Studium,Addison-Wesley 2001
2. Leszek Maciaszek and Bruc Lee Liong: Practical Software Engineering: A Case-Study Approach. Addison-Wesley 2005
3. Kim Walden, Jean-Marc Nerson : Seamless Object-Oriented Software Architecture - Analysis and Design of Reliable Systems, Prentice Hall, 1995
4. Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides: Design Patterns - Elements of Reusable Object-Oriented Software, Addison-Wesley 1995
5. Eric Freeman, Elisabeth Freeman, Kathy Sierra, Bert Bates: Head First Design Patterns, O'Reilly, 2004 (1th)

Organization: The course is organized in combination with the course Software Techniques Lab that adds the practical programming and project experience aspects to this course. Because this course provides the conceptual background for the lab, the course is mainly scheduled for the first part of each summer term.

Hours per Week / Semester: 4/summer	**Teaching Method:** Lectures (1) and tutorials (1)
Credits: 3	**Examination:** 90 minute written examination and *assessments*

Basics of Information Technology: Software Techniques Laboratory

Praktikum zur Software Entwicklung

Prerequisites: see *Software Development Techniques*

Objective: To expose students to the problems involved in developing complex applications in software projects organized as interacting as well as concurring subprojects/groups. Students gain a first insight into the problems caused by software complexity and project work.
Contents: The lab provides a guided tour through all phases of developing a complex software project using state-of-the-art technology for object-orientied programming languages, libraries, software development environments, testing, logging and documentation tools as well as version control systems.
Organization: The course is held in the last three month of the term after the prerequisites have been discussed in the *Software Techniques* course. The course is mainly organized as a lab project where participants are required to word in interacting subgroups to implement a common software project.

Hours per Week / Semester: 4/summer	**Teaching Method:** Lab Project (4)
Credits: 6	**Examination:** 20 minute oral examination and assessments

Advanced Studies (3rd - 5th year)

Practical Computer Science: Distributed and Mobile Systems

Verteilte und Mobile Systeme

Note: the following courses (PI-EVMS-B, PI-AVSM-M, PI-Prakt-M) are offered as a 2 semester curriculum for specializing in the field of practical computer science; at least PI-EVMS-B and PI-AVSM-M should be enrolled in the prescribed order. Depending on the specific topics discussed in the seminars (PI-Sem-M, see below), attendance to the seminars may be permitted without EVMS-B and PI-AVSM-M.

Introduction to Distributed and Mobile Systems (PI-EVMS-B)

Einführung in Verteilte und Mobile Systeme

Prerequisites: A basic understanding of computer networks, operating systems at least as it is offered by the course *Computer Architecture and Operating Systems* (basic studies), experience in Java programming.
Objective: To expose students to the problems involved in designing and programming parallel and distributed applications. To gain an in-depth understanding of the most important paradigms used in the area.
Contents: The course gives an introduction into the characteristics and most important applications of distributed systems, discusses the technical basics as well as typical distributed algorithms and provides a first overview over state-of-the-art middleware systems: (1) Introduction: characteristics, pros/cons for distributed systems, typical applications;

(2) Basics and Technological Background: states, events, processes, non-determinism, concurrency, dependencies, cooperation vs. competition, deadlocks, fairness, starvation; classification of computer architectures, static and dynamic computer networks, operating system issues, tasks and threads
(3) Interaction Paradigms: Heterogeneous systems and protocols, shared vs. distributed memory, message passing: ports, channels, mailboxes, synchronous vs. asynchronous; Client/Server: RPC, naming, binding, protocols, parameter handling, error handling semantics, call backs; Group communication: broadcast and multicast, group management, semantics issues; LINDA coordination. Throughout this chapter, practical issues using Java are handled in assignments: Threads, synchronization, socket communication (stream and datagram), Java RMI, Java Spaces;
(4) Basic Distributed Algorithms: real and logical time in distributed systems, message ordering, distributed mutual exclusion, termination and deadlock detection, consistent global snapshots, agreement protocols;
(5) Distributed Middleware: (sketch): single-system image, failure tolerant systems, replication of active and passive components, consistency issues, short overview of state-of-the-art middleware systems
Literature

1. Andrew S. Tanenbaum, Marten van Steen: *Distributed Systems*, Prentice Hall 2003, 803pp., ISBN 0-13-088893-1
2. G. Coulouris, J. Dollimore and T. Kindberg: *Distributed Systems - Concepts and Design*, 2002(3rd), Addison-Wesley
3. Pradeep K. Sinha: *Distributed Operating Systems - Concepts and Design* IEEE CS Press, 1997, ISBN 0-7803-1119-1
4. Nancy A. Lynch: *Distributed Algorithms*.Morgan-Kaufmann Publ. , 2000 (5^{th})

Organization: The course is offered each winter term, consists of 3 hours lecture and 1 hour tutorial/lab each week organized as 2 hour tutorial each second week. Participants are assumed to work on 3-4 programming assignments throughout the term.

Hours per Week / Semester: 4/winter	**Teaching Method:** Lectures (3) and tutorials (1)
Credits: 6	**Examination:** 90 minute written examination and *part* of final oral examination (20 minutes)

Architecture of Distributed Systems and Middleware (PI-AVSM-M)

Architektur verteilter Systeme und Middleware

Requirements: Basic understanding of distributed systems issues as it is offered, e.g., in the course PI-EVMS-B: *Introduction to Distributed and Mobile Systems*, practical experience with programming simple distributed software systems.
Objective: To gain an in-depth understanding of the most important middleware platforms, an overview of their specific pros and cons as well as

insights in the principles of building and maintaining complex distributed systems architectures.
Contents: The first part of the course describes the essentials of distributed middleware systems based on state-of-the-art middleware products like, e.g., Message Queueing Systems, CORBA, DCOM/COM+, Jini, EJB, .NET, Webservices etc. Moreover, the role of protocols and standards like XML, SOAP, WSDL, UDDI etc. are discussed. Advanced topics include general aspects of component based systems (e.g. EJB3 and Corba CCM), approaches to realize service oriented architectures (SOA) and higher abstraction levels like workflow and business processes based on SOA (WS-BPEL, ebXML etc.). Moreover, specific issues like infra-structure networks vs. Peer-to-Peer models, software platforms and architectures for mobile systems are sketched.
Organization: The course is offered each summer term, consists of 2 hours lecture and 2 hour tutorial/lab each week. Participants are assumed to work on programming assignments and (small) projects utilizing middleware technologies throughout the term.

Hours per Week / Semester: 4/summer	**Teaching Method:** Lectures (2) and tutorials (2)
Credits: 6	**Examination:** 90 minute written examination and *part* of final oral examination (20 minutes)

Distributed and Mobile Software Project (PI-Prakt-M)

Projekt zu Verteilte und Mobile Systeme

Requirements: Understanding of distributed and /or mobile systems issues (depends on the specific topic of the project) as offered, e.g., in the courses *Introduction to Distributed and Mobile Systems* and *Architectures for Distributed Systems and Middleware*, practical experience with programming distributed software systems.
Objective: To gain an in-depth understanding of the practical problems related to distributed programming and software projects using multi-vendor middleware platforms. To apply theoretical concepts of distributed and mobile systems when designing, implementing and testing distributed software.
Contents: After a short introduction in (typically) a middleware system like CORBA, Java-related technology, .NET etc, students work in cooperating and/or concurring groups on a mid-size distributed software project continuously over the term.

Hours per Week / Semester: 4 (in between terms: Sep.-Oct.)	**Teaching Method:** Guided Project (working in groups)
Credits: 6	**Examination:** Short presentations of technical topics used for the project, presentation of the final results: software architecture, demonstration, handbook, lessons learned; production of a poster summarizing the project and its outcome. *part* of final oral examination (20 minutes)

Seminar in Distributed and Mobile Systems (PI-Sem-M)

Master-Seminar zu Verteilte und Mobile Systeme

Requirements: Understanding of the basics of the topics handled in the seminar, i.e. basics of software engineering, operating systems, distributed and mobile systems,
Objective: To gain an in-depth understanding of state-of-the-art problems and solutions related to specific research topics of the working group for practical computer science. To learn how to search for and evaluate research papers with background information on a specific topic, to understand and present the contents of recent research papers in written and oral form to an audience of students.
Contents: Depends on the topics of current research work of the distributed and mobile systems working group, e.g., complex software systems modelling and engineering, specific topics from the area of distributed and mobile systems, agent technology and so on.
Organization: The seminar is offered each term. Participants are assumed to work on research literature assignments before start of the term, present a talk, prepare an essay and participate actively in seminar discussions.

Hours per Week / Semester: 2/each semester	**Teaching Method:** Seminar
Credits: 3	**Examination:** Essay (15 pages), 30 Minutes presentation, continuous assessment