

# MASTER DIGITAL TRANSFORMATION MASTER PROGRAMME

2019

**Module Handbook**

**Version 14**

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## Study Programme overview

1 <sup>st</sup> semester (winter semester)						
	module examin- ation	mod-nr/ exam-nr	student workload			ECTS points
			contact hours		self-study (hrs)	
			SWS <sup>1</sup>	hours		
Innovation Driven SE	MOD1-01	48010/11	4	60	120	6
Software Architectures	MOD1-02	48020/21	4	60	120	6
Digital Systems 1	MOD1-03	48030/31	4	60	120	6
R&D Project Management	MOD1-04	48040/41	4	60	120	6
Scientific & Transversal Skills 1	MOD1-05	48050/51	4	60	120	6
<b>Total</b>	<b>5</b>		<b>20</b>	<b>300</b>	<b>600</b>	<b>30</b>
2 <sup>nd</sup> semester (summer semester)						
	module examin- ation	mod-nr/ exam-nr	student workload			ECTS points
			contact hours		self-study (hrs)	
			SWS <sup>1</sup>	hours		
Usability Engineering	MOD2-01	48060/61	4	60	120	6
Software-intensive Solutions	MOD2-02	48070/71	4	60	120	6
Digital Systems 2	MOD2-03	48080/81	4	60	120	6
Scientific & Transversal Skills 2	MOD2-04	48090/91	4	60	120	6
Elective 1 *	MOD2-05		4	60	120	6
<b>Total</b>	<b>5</b>		<b>20</b>	<b>300</b>	<b>600</b>	<b>30</b>
3 <sup>rd</sup> semester (winter semester)						
	module examin- ation	mod-nr/ exam-nr	student workload			ECTS points
			contact hours		self-study (hrs)	
			SWS <sup>1</sup>	hours		
Elective 2 *	MOD3-01		4	60	120	6
Elective 3 *	MOD3-02		4	60	120	6
Research Project (Thesis)	MOD3-03	48190/91	0	0	540	18
<b>Total</b>	<b>3</b>		<b>8</b>	<b>120</b>	<b>780</b>	<b>30</b>


4 <sup>th</sup> semester (summer semester)						
	module examin- ation	mod-nr/ exam-nr	student workload			ECTS points
			contact hours		self-study (hrs)	
			SWS1	hours		
<b>Master Thesis and Colloquium</b>	P		0	0	900	30
<b>Total</b>	<b>5</b>		<b>20</b>	<b>300</b>	<b>600</b>	<b>30</b>

<sup>1</sup> SWS= weekly hours per semester

\*cf. Attachment 2

<b>Innovation Driven Software Engineering (MOD1-01)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48010/11	180 h	6	1	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Innovation Driven Software Engineering		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b>  Innovation driven software engineering touches every aspect of modern software development. Today's software emphasizes novelty, usability, and joy of use. Modern software is usually created in creative and highly iterative processes. Many steps in these processes involve potential users. This integration of the user can be addressed with the so-called Design Thinking method.  Refined ideas and prototypes can be the foundation for new startup companies. One way to check the viability is the Business Model Canvas. Agile Software Development puts the focus back on user feedback and iterations. The agile development process is accompanied with an extensive tool chain for designing and creating software solutions. For instance, UML Diagrams, Version control systems, Bug tracker and ticket management systems.				
<b>3</b>	<b>Course Structure</b>  <ul style="list-style-type: none"> <li>• Design Thinking</li> <li>• Business Model Canvas</li> <li>• Legacy process models</li> <li>• Agile Software Development</li> <li>• Agile Manifesto best practices</li> <li>• UML Modelling</li> <li>• Tooling like git, Bug tracker and ticket management systems, Checkstyle, etc.</li> </ul>				
<b>4</b>	<b>Application Focus</b>  <ul style="list-style-type: none"> <li>• Practical exercises</li> <li>• Realizing a real-world project within a block-week in a team</li> </ul>				
<b>5</b>	<b>Scientific Focus</b>  <ul style="list-style-type: none"> <li>• Written assignment: literature review in the style of a scientific paper up to 10 pages</li> <li>• Performing a survey based on relevant scientific methods</li> </ul>				
<b>6</b>	<b>Parameters</b>  <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – winter semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> </ul>				

	<ul style="list-style-type: none"> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge (40%): Written Exam at the end of the course, Practical Skills (40%): realizing a small real-world project within the lecture related topics of innovation driven software engineering and Scientific Competences (20%): written paper (literature review, approx. 10 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>• Teaching staff: Prof. Dr. Sabine Sachweh, external lecturers from industry and/or partner universities, PhD students from IDiAL</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows the theoretical background of the design thinking method</li> <li>• Knows different software development processes especially agile software development</li> <li>• Knows required steps and processes for agile software development</li> <li>• Knows how to express software architectures based on the UML Diagrams</li> <li>• Knows how to use tools like git, checkstyle, bug tracking and issue management systems</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can conceptualize a software based on the design thinking method</li> <li>• Can apply and choose between software development processes</li> <li>• Can setup and manage a team based on agile principles</li> <li>• Can work on a software development project</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can work in a team on scientific topics</li> <li>• Can present and defend scientific results in front of an audience</li> <li>• Can discuss the topics related to the lecture</li> <li>• Can understand related topics and translate between different domains</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on innovation driven software engineering</li> <li>• Practical Skills: Project work, Labs, and Exercises</li> <li>• Scientific Competences: extract information for a given topic in a small group and sum the results up</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>MOD2-01 – Usability Engineering</p> <p>MOD-E03 – Human Centered Digitalization</p> <p>Input from:</p> <p>None</p>
<b>10</b>	<p><b>References</b></p> <p>Solving Problems with Design Thinking - Ten Stories of What Works, Jeanne Liedtka, Andrew King, Kevin Bennett, Columbia Business School Publishing, 2013, ISBN: 0231163568</p>

	<p>Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Alexander Osterwalder, Yves Pigneur, John Wiley &amp; Sons, 2010, ISBN: 9780470876411 </p> <p>Software Engineering, Ian Sommerville, Addison Wesley Pub Co Inc, 2015, ISBN: 0133943038</p>
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<b>Software Architectures (MOD1-02)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48020/21	180 h	6	1	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Software Architectures		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<p><b>Course Description</b></p> <p>In recent years' new architectural styles have emerged to cope with the increasing need of highly scalable and distributed systems. Among them are Microservices and Self-Contained Systems. The resulting systems are characterized by being componentized into independent services which communicate using well-defined interfaces.</p> <p>This course the students learn about modern software architecture paradigms, both conceptually and practically. Additionally, subjects related to the operation of such systems are covered, such as infrastructure-technologies and particular challenges of operation like scaling or load balancing.</p> <p>In addition to the lectures, the students have the opportunity to apply their knowledge in project-based group activities.</p>				
<b>3</b>	<p><b>Course Structure</b></p> <ul style="list-style-type: none"> <li>• Historical development of software architecture paradigms.</li> <li>• Characteristics of modern architectural styles.</li> <li>• Designing Microservices and Self-Contained Services.</li> <li>• Developing Microservices and Self-Contained Services.</li> <li>• Infrastructure, deployment, and operation: Methods, technologies and challenges.</li> </ul>				
<b>4</b>	<p><b>Application Focus</b></p> <p>To complement the lectures and enable the students to apply the covered topics, there will be a project. Their students will work in small groups to participate in the design and development of a significant application.</p>				
<b>5</b>	<p><b>Scientific Focus</b></p> <p>Written assignment: literature review in the style of a scientific paper up to 10 pages Performing a survey based on relevant scientific methods</p>				
<b>6</b>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – winter semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> </ul>				



	<ul style="list-style-type: none"> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge (40%): Theoretical knowledge (40%): Written Exam at the end of the course, Practical Skills (40%): Individual programming task, realizing a small real-world project within the lecture related topics of software architectures and Scientific Competences (20%): written paper (literature review, approx. 10 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>• Teaching staff: Prof. Dr. Sabine Sachweh, external lecturers from industry and/or partner universities, PhD students from IDiAL</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows the concepts and structure of modern software architecture styles</li> <li>• Knows technologies and tools related to the operation of modern software architectures</li> <li>• Knows particular challenges of operating distributed systems</li> <li>• Knows how to analyze an application by different metrics</li> <li>• Knows to maintain and operate a distributed system</li> <li>• Knows how to distributed a system based on workload of particular components</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can critically evaluate the suitability of an architectural style given a particular problem</li> <li>• Can design, develop and operate leveraging the lecture topics</li> <li>• Can assess and improve an existing software architecture</li> <li>• Can analyze a distributed system by different application metrics</li> <li>• Can distribute a container-based system by workload</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss and assess the differences between various architectural styles</li> <li>• Can communicate and explain architectural decisions</li> <li>• Can work in a team on scientific topics</li> <li>• Can demonstrate and discuss results in a group</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on software architecture models, tool tutorials</li> <li>• Practical Skills: Projects, Labs &amp; Exercises, small project</li> <li>• Scientific Competences: student research group on SW Architectures</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>MOD2-02 – Software-intensive Solutions</p> <p>MOD-E01 – Software Engineering Project</p> <p>Input from:</p> <p>None</p>
<b>10</b>	<p><b>References</b></p> <p>Newman, S.; Building Microservices, O'Reilly Media, 2016</p> <p>Wolff, E.; Microservices: Flexible Software Architecture, Addison-Wesley, 2016</p>

<b>Digital Systems 1 (MOD1-03)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48030/31	180 h	6	1	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Digital Systems 1		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b> The module is intended to give students to competence to understand, analyze, develop, set up and evaluate digital systems based on the latest scientific state of the art. This involves the basic layers of the Internet-of-Things (IoT) stack including M2M devices and gateways, the relevant protocol stacks for IoT and the relevant communication network technologies (both wireless and wireline). During the module, students will set up a complete IoT device with all relevant functionality to be connected to the cloud. Recent topics from research projects (e.g. connected car, smart home) complement the course with the aim to stimulate discussion of scientific results.				
<b>3</b>	<b>Course Structure</b> <ol style="list-style-type: none"> <li>1. Introduction to M2M and IoT devices and gateways</li> <li>2. Processor architecture for embedded devices and gateways</li> <li>3. IP based communication</li> <li>4. IoT and M2M protocols</li> <li>5. Communication gateway architectures</li> <li>6. Wireline communication networks and standards</li> <li>7. Wireless communication networks and standards</li> <li>8. Case study of a state-of-the-art application, e.g. connected car or industry 4.0</li> </ol>				
<b>4</b>	<b>Application Focus</b> Project IoT System: students will set up and implement a IoT system with an M2M device, a gateway with wireless and wireline transmission and a IoT cloud connection. The respective case study will be taken from a recent R&D project or an industry case. The result will be a demonstrator system.  Trainings: students attend a training for the Siemens Embedded Software Developer tool chain				
<b>5</b>	<b>Scientific Focus</b> Students will do a scientific evaluation of the potential of IoT usage in a specific domain (e.g. eMobility charging systems) based on recent scientific literature.				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – winter semester</li> </ul>				

	<ul style="list-style-type: none"> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge: Written Exam at the end of the course (50%) and Practical Skills: Individual programming task (50%): implementation of an IoT device, gateway and protocol stack system =&gt; demonstration of the result</li> <li>• Teaching staff: Prof. Dr. Ingo Kunold, staff from IKT institute, guest lecturers from joint research projects</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows relevant theoretical foundations of M2M and IoT</li> <li>• Knows relevant gateway and processor architectures</li> <li>• Knows relevant protocol stacks and communication systems</li> <li>• Know methodical background of IoT system design</li> <li>• Is aware of critical limitations of IP based protocols, esp. in real time tasks</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can model IoT and M2M systems</li> <li>• Can implement embedded systems into IoT systems</li> <li>• Can apply state of the art tools for SW for embedded systems</li> <li>• Can select IoT and M2M platforms according to system requirements</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss IoT device and gateway systems with experts</li> <li>• Can lead cross domain design for IoT systems</li> <li>• Understands SW and HW experts and translates between different domains</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on IoT devices and protocols, tool tutorials</li> <li>• Practical Skills: Projects, Labs &amp; Exercises, small project with an IoT device and protocol stack</li> <li>• Scientific Competences: own research on IoT in e-mobility</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>MOD2-03 – Digital Systems 2</p> <p>Input from:</p> <p>none</p>
<b>10</b>	<p><b>References</b></p> <p>t.b.d.</p>

<b>R&amp;D Project Management (MOD1-04)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48040/41	180 h	6	1	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> R&D Project Management	<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students	
<b>2</b>	<b>Course Description</b> <p>The course R&amp;D project management is focusing on processes, methods and tools for the management of innovative research and development projects in engineering. R&amp;D projects are characterized by creativity and a high degree of innovation and uncertainty. Advanced project management methodology has to deal with the uncertainty and has to foster creativity. Apart from this general problem, R&amp;D project methodology has to be aligned with the engineering processes and with the different engineering domains. Topics like quality management, configuration management and specific tools for risk management are part of the methodology, too. The course enables students to understand and structure R&amp;D projects and to choose appropriate tools and methods based on a proper analysis of the project characteristics. The students are able to tailor the methodology and they understand the remaining gaps in the methodology. They can develop new project management methods and tools to fill the gaps and they can do research to assess the effectiveness and efficiency of project management methodology in R&amp;D. The course is based on one main project case study and several small cases for specific topics.</p>				
<b>3</b>	<b>Course Structure</b> <ol style="list-style-type: none"> <li>1. Characteristics of R&amp;D projects</li> <li>2. Project management processes:               <ol style="list-style-type: none"> <li>a. planning, controlling (cost, time, quality)</li> <li>b. agile &amp; lean</li> <li>c. V-model</li> </ol> </li> <li>3. Milestones and Reviews</li> <li>4. Risk Management for R&amp;D Projects</li> <li>5. Configuration &amp; Release Management</li> <li>6. Change and Claim Management (incl. Patents)</li> <li>7. Quality Management (incl. CMMI)</li> <li>8. KPIs and Scorecards</li> <li>9. Large R&amp;D projects and Cross Domain Projects</li> <li>10. Management of R&amp;D organizations</li> </ol>				
<b>4</b>	<b>Application Focus</b> <p>Block workshop: students attend an interdisciplinary one-week workshop where they prepare and plan a project for an industry case (together with EuroMPM and Master ESM)</p>				
<b>5</b>	<b>Scientific Focus</b> <p>Students prepare a homework and a presentation on an individually selected topic from recent project management research.</p>				
<b>6</b>	<b>Parameters</b>				

	<ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4             <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – winter semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge: Oral exam at the end of the course (40%), Practical Skills: Group assessment on results of block week (40%) and Scientific Competences: paper presentation (20%)</li> <li>• Teaching staff: Prof. Dr. Carsten Wolff, Dr. Oliver Hempel (Industry Lecturer Honeywell Elster)</li> </ul>
<p><b>7</b></p>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Students know the basic body of knowledge for project management</li> <li>• Students know processes, methods and tools for risk management for R&amp;D projects (e.g. FMEA, @risk)</li> <li>• Students know processes, methods and tools for configuration management (esp. from SW engineering)</li> <li>• Students know processes, methods and tools for change and claim management</li> <li>• Students know processes, methods and tools for quality management according to ISO9001 and TS16949</li> <li>• Students understand the importance of Reviews in R&amp;D projects</li> <li>• Students understand the main challenges of large R&amp;D projects</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Students can tailor processes and methods to the respective projects</li> <li>• Students can apply the respective project management methodology</li> <li>• Students can assess R&amp;D projects and can extract relevant characteristics</li> <li>• Students can develop new methods according to gaps in the existing methodology</li> <li>• Students can do the complete planning and preparation of a real project case</li> <li>• Students can develop relevant KPIs and scorecards for measuring effectiveness and efficiency</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Students develop an attitude to project management according to engineering standards</li> <li>• Students show a quality attitude according to engineering standards</li> <li>• Students manage projects based on structured and well defined processes and in depth analysis</li> <li>• Students can achieve high effectiveness and efficiency in running complex and innovative R&amp;D projects</li> <li>• Students understand the differences between small and large projects and act accordingly</li> </ul>
<p><b>8</b></p>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: lectures on project management processes, methods and tools</li> <li>• Practical Skills: interdisciplinary block week</li> <li>• Scientific Competences: individual research paper + presentation</li> </ul>

<b>9</b>	<b>Course mapping</b>  Input for:  Usability Engineering (MOD2-01)  Requirements Engineering (MOD-E02)  Managing Digital Change (MOD-E08)  Input from:  none
<b>10</b>	<b>References</b>  PMBOK® - 4th edition, PMI® 2008.  Kerzner, Harold: Project Management: A Systems Approach to Planning, Scheduling, and Controlling, 10th edition, New York 2009  ICB - IPMA Competence Baseline, Version 3, PMA/GPM-Eigenverlag 1999  INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities, 4th Edition, INCOSE, 2015, ISBN: 978-1-118-99940-0

<b>Scientific &amp; Transversal Skills 1 (MOD1-05)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48050/51	180 h	6	1	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Scientific & Transversal Skills 1		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b>  The course is intended to form a tailored program for new students according to their prior knowledge, educational and professional background. It is intended to offer a wrap up and to close gaps according to the previous bachelor degree, to converge the students from different backgrounds into one international classroom and to prepare them for the educational concepts of the Master's programme. Students select compact courses worth 6 ECTS in total on topics relevant for the further study programme. These compact courses will enable students with different backgrounds to get a smooth start into the other master modules. The selection of courses is need based and will be assessed by interviewing the students, by doing tests (where necessary) and by consulting.				
<b>3</b>	<b>Course Structure</b>  In the initial set up of the master a selection of 8 compact courses are offered. More can be added according to the analysis of the needs of actual students:  <ol style="list-style-type: none"> <li>1. Compact Electronics Course (Microcontroller-Lab)</li> <li>2. Compact Programming Course (Java, C#)</li> <li>3. Modeling of Embedded Systems (UML)</li> <li>4. Tools and Techniques for Digital Systems Design (Eclipse)</li> <li>5. Mini Projects (Group Projects, with other Master's programmes)</li> <li>6. Research Methods and Tools – part A (RMT-A): (Introduction to Scientific Domain, Literature Review, Conceptual Frameworks)</li> <li>7. International Project Communication (English)</li> <li>8. Engineering Communication 1 (German A1, or other foreign language for Germans)</li> </ol>				
<b>4</b>	<b>Application Focus</b>  Depending on choice of courses				
<b>5</b>	<b>Scientific Focus</b>  Depending on choice of courses				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>– Contact hours: 60</li> <li>– Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – winter semester</li> </ul>				

	<ul style="list-style-type: none"> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course:</li> <li>• Assessment of the course: Depending on choice of courses</li> <li>• Teaching staff: Prof. Dr. Rolf Schuster, PhD students of IDiAL for compact courses, external Professor from partner university for “Research methodology 1”, language trainers and coaches e.g. from Auslandsgesellschaft</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows the foundations of each topic at least up to bachelor knowledge</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can apply the knowledge in the upcoming master courses</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can assess the gaps in own knowledge</li> <li>• Can use a variety of tools, online-courses, tutorials to close the gap in own responsibility</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <p>Compact courses will follow a similar structure:</p> <ul style="list-style-type: none"> <li>- 1 day introduction in the first two weeks of the first semester, mini-tests to assess the prior knowledge and to define the gap. Definition of the training need and selection of trainings an exercises</li> <li>- 0,5 day assessment and tutorial in the week before Christmas (block week)</li> <li>- Tutorials on each Friday throughout the whole semester</li> <li>- Access to e-learning modules and MOOCs for each topic</li> <li>- Literature recommendations and provision of exercises</li> <li>- Submission of homework for assessment and advice by tutors</li> </ul> <p>Language and communication trainings will be done on a weekly basis, e.g. Monday afternoon + evening (in connection with external trainers, e.g. from Auslandsgesellschaft), external lecturer for “Research Methods and Tools – part A (RMT-A)”</p>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>Depending on choice of courses</p> <p>Input from:</p> <p>none</p>
<b>10</b>	<p><b>References</b></p> <p>Depending on the chosen set of compact courses</p>



<b>Usability Engineering (MOD2-01)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48060/61	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Usability Engineering		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<p><b>Course Description</b></p> <p>The course Usability Engineering is focusing on the essential methods and tools to evaluate and measure the effectiveness, efficiency and the joy of use with which a user and perform a task with a given system. The reoccurring scheme throughout the course is the User Centered Design Process. The students will learn how to observe and specify a context of use, derive requirements from it, create a prototype and evaluate it. For all those parts of the processes students will specific tools and methods will be introduced, for different phases during the software development Students will learn about the work in the area of usability engineering from a theoretical viewpoint, by studying state-of-the-art research publications, as well as from a practical point of view, by project examples and case studies. These methods and tools will be applied as well as critically evaluated and checked for potential of improvement.</p>				
<b>3</b>	<p><b>Course Structure</b></p> <ol style="list-style-type: none"> <li>1. Introduction               <ol style="list-style-type: none"> <li>a. Motivation</li> <li>b. Definition Usability Engineering</li> </ol> </li> <li>2. Processes               <ol style="list-style-type: none"> <li>a. Usability Engineering -Processes</li> <li>b. Integration into IT-projects</li> <li>c. Potential conflicts</li> <li>d. Communicating Usability</li> </ol> </li> <li>3. Usability Engineering Tools and Methods               <ol style="list-style-type: none"> <li>a. Analyzing context of use</li> <li>b. Requirements management</li> <li>c. Concepts</li> <li>d. Evaluation</li> </ol> </li> <li>4. Additional topics: Coordinated with the student's interests one to three of the following topics will be chosen. The list will be adapted to take changes in the state of the art into account.               <ol style="list-style-type: none"> <li>a. Mobile Computing</li> <li>b. Individual software solutions</li> <li>c. Consumer- vs. Business-Software</li> <li>d. Industrial solutions</li> </ol> </li> </ol>				
<b>4</b>	<p><b>Application Focus</b></p> <p>Block workshop: students attend an interdisciplinary one-week workshop where they apply the Usability Tools and Methods for an industry case (potentially together with EuroMPM, Master ESM and Master Computer Science), for example in an early project state with prototyping or in a later project state with focus on evaluation and last changes</p>				

5	<p><b>Scientific Focus</b></p> <p>Students prepare a homework and a presentation on an individually selected topic from recent usability engineering research, related to the project they worked on during the block workshop for the application focus, including a reflection on the lessons learned from practice in comparison to research.</p>
6	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4             <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge (40%): Written or oral Exam at the end of the course, Practical Skills (40%): realizing a small real-world project using usability engineering tools and methods during a block week and Scientific Competences (20%): written paper (literature review, approx. 10 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>• Teaching staff: Prof. Dr. Christian Reimann, external lecturers from partner universities, e.g. Prof. Dr. Rimante Hopiene (Technische Universität Kaunas, KTU)</li> <li>•</li> </ul>
7	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows relevant theoretical foundations of usability engineering</li> <li>• Knows established usability engineering tools and methods (AB-Tests, GOMS, Interviews, Usability-Lab Tests, Remote-Tests, etc.)</li> <li>• Knows the applicability of those tools and methods in a given project situation</li> <li>• Knows communication concepts for different target groups (professional peers, user groups, management, etc.)</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can observe, recognize and evaluate user behavior and behavioral patterns (e.g. analyzing video protocols from user tests)</li> <li>• Can analyze context of use, derive requirements, prototype and evaluate a software system</li> <li>• Can adapt and improve those methods and tools for new application areas</li> <li>• Can develop communication concepts for new/adapted target groups</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can provide a self-reliant evaluation of the recent research in a (small) given area</li> <li>• Can relate and evaluate the methods and tools into the recent scientific publications</li> <li>• Can critically reflect behavior (own and well as others) in general, as well as in a given situation</li> </ul>

<b>8</b>	<b>Teaching and training methods</b> <ul style="list-style-type: none"><li>• Theoretical knowledge: e-learning modules and (live-)video lectures on usability engineering</li><li>• Practical Skills: Projects, Labs &amp; Exercises, block week with selected tools and methods</li><li>• Scientific Competences: student research group on usability engineering</li></ul>
<b>9</b>	<b>Course mapping</b>  Input for: <ul style="list-style-type: none"><li>• Research Project Thesis (MOD3-03)</li></ul> Input from: <ul style="list-style-type: none"><li>• Innovation Driven Software Engineering (MOD1-01)</li><li>• R&amp;D Project Management (MOD1-04)</li><li>• Scientific &amp; Transversal Skills 1 (MOD1-05)</li></ul>
<b>10</b>	<b>References</b>  Jakob Nielsen, Usability Engineering, Elsevier, 1994  Carol M. Barum, Usability Testing Essentials, Elsevier, 2010  Don Norman, The design of everyday things, Basic Books, 2013  Jeffrey Rubin and Dana Chisnell, Handbook of Usability Testing: Howto Plan, Design, and Conduct Effective Tests, Wiley, 2008

<b>Software-intensive Solutions (MOD2-02)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48070/71	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Software-intensive Solutions		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b> <p>This course has the aim to walk through the technology stack of an Internet of Everything (IoE) solution. Students will get a holistic view on the processes, components, methods and tools and their connections and dependencies. Relevant architectures and concepts are put into the context of complete IoE solutions. This holistic view starts with the level of the devices that are connected to the internet like mobile devices or sensors and actuators. Realizing such systems commonly requires the communication with sensors and actuators on the hardware-side and communication with cloud services on the software-side. The corresponding cloud service has to process and store data like sensor values and analyze these with artificial intelligence or machine learning, which must be taken into account while developing such systems. The course intends to put the topics addressed by the first semester modules into the overall context. This forms (as a connecting element) the bridge to the more specific elective modules.</p>				
<b>3</b>	<b>Course Structure</b> <ul style="list-style-type: none"> <li>• Architectures of Internet of Everything solutions</li> <li>• APIs for Sensors and Actuators</li> <li>• Communication protocol stacks and their intergration</li> <li>• Database integration for IoE (Time-Series etc.)</li> <li>• Application of Data Science in IoE solutions (Big-Data, Smart Data, etc.)</li> <li>• Application of Artificial Intelligence and Deep-Learning in IoE solutions</li> <li>• Integration of cloud-based services</li> </ul>				
<b>4</b>	<b>Application Focus</b> <p>Within a block-week real-world project together with companies are realized. Students test and test these projects within the User Innovation Center.</p>				
<b>5</b>	<b>Scientific Focus</b> <p>Written assignment: literature review in the style of a scientific paper up to 10 pages</p>				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> </ul>				

	<ul style="list-style-type: none"> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge (40%): Written Exam at the end of the course, Practical Skills (40%): realizing a small real-world project within the lecture related topics of software intensive solutions and Scientific Competences (20%): written paper (literature review, approx. 10 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>• Teaching staff: Prof. Dr. Sabine Sachweh, external lecturers from industry and/or partner universities, PhD students from IDiAL</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Know the difference between IoT and IoE</li> <li>• Know the different architectures of Internet of Things</li> <li>• Know several related technology stacks</li> <li>• Know the most relevant communication protocols and APIs</li> <li>• Know the requirements of various types of databases</li> <li>• Know the difference between actuating elements, sensors, and devices</li> <li>• Know the purpose of artificial intelligence</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can identify and define the requirements for an Internet of Everything application</li> <li>• Can apply different tools for designing an IoE application</li> <li>• Can assess existing solutions in the area of IoE and cloud-services</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss Internet of Everything in the scientific context</li> <li>• Can present and defend results</li> <li>• Can understand and translates IoE related stuff between different domains</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on software-intensive systems, tool tutorials</li> <li>• Practical Skills: Project work within the User Innovation Center, Labs, and Exercises</li> <li>• Scientific Competences: extract information of published papers about the relevant topics for the provided course-content</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>MOD-E01 Software Engineering Project</p> <p>Input from:</p> <p>MOD1-02 Software Architectures</p> <p>MOD1-03 Digital Systems 1</p>
<b>10</b>	<p><b>References</b></p> <p>Prof. Dr.-Ing. habil. Hartmut Janocha, Adaptronics and Smart Structures, Springer 2007</p> <p>Taewan You, Toward the future of Internet architecture for IoE, ICTC 2016</p> <p>Emil Vassev, Mike Hinchey, Awareness in Software-Intensive Systems, IEEE Computer Society 2012</p>

Marcelo Benites Gonçalves, Everton Cavalcante, Towards a Conceptual Model for Software-Intensive System-of-Systems, ieee international conference on systems, man and cybernetics 2014

Grayson Honan, Tolga Soyata, Internet-of-Everything Oriented Implementation of Secure Digital Health (D-Health) Systems, ISCC 2016

<b>Digital Systems 2 (MOD2-03)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48080/81	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Digital Systems 2		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b> <p>The module is expanding student competence to understand, analyze, develop, set up and evaluate digital systems based on the latest scientific state of the art. This involves mainly the topics security in cyber-physical systems (CPS) and operating systems. During the module, students will develop a security concept for the IoT devices from Digital Systems 1. Furthermore, they will structure an application with real-time requirements according to the operator controller module (OCM) and select an appropriate operating system for the device. Recent topics from research projects (e.g. smart grid, eMobility) complement the course with the aim to stimulate discussion of scientific results.</p>				
<b>3</b>	<b>Course Structure</b> <ol style="list-style-type: none"> <li>1. Introduction to internet security for CPS</li> <li>2. Architectures for trusted platforms</li> <li>3. Secure communication</li> <li>4. Intrusion detection and advanced methods in CPS</li> <li>5. Authentication, data protection and privacy and IoT systems</li> <li>6. Introduction to the Operator-Controller-Module</li> <li>7. Real-time processing</li> <li>8. Operating systems (OS) and databases for embedded systems</li> <li>9. Case study of a state-of-the-art application, e.g. smart grids</li> </ol>				
<b>4</b>	<b>Application Focus</b> <p>Project IoT System: students will the security system for the IoT system from the previous semester. Furthermore, they will implement an application with real-time aspects based on a selected operating system. The respective case study will be taken from a recent R&amp;D project or an industry case. The result will be a demonstrator system.</p> <p>Trainings: students attend a training for CPS security tools from Institute for Internet Security.</p>				
<b>5</b>	<b>Scientific Focus</b> <p>Students will do a scientific evaluation of the security issues in a specific domain (e.g. eMobility charging systems) based on recent scientific literature.</p>				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> </ul>				

	<ul style="list-style-type: none"> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competences</li> <li>• Assessment of the course: Theoretical knowledge: Written Exam at the end of the course (50%) and Practical Skills: Individual programming task (50%): implementation of an IoT security system in device, communication and cloud level (e.g. based on Eclipse IoT stack) =&gt; demonstration of the result</li> <li>• Teaching staff: Prof. Dr. Ingo Kunold, staff from IKT institute, guest lecturers from joint research projects</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows relevant theoretical foundations of internet security</li> <li>• Knows relevant architectures for trusted platforms</li> <li>• Knows relevant secure communication protocols</li> <li>• Know the theoretical background of the operator controller module (OCM)</li> <li>• Know methodical background of real time system design</li> <li>• Is aware of critical limitations of CPS security and real-time OS</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can develop a secure IoT system</li> <li>• Can implement real-time OS into IoT systems</li> <li>• Can apply state of the art tools for CPS security</li> <li>• Can select embedded OS according to system requirements</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss CPS security issues with experts</li> <li>• Can lead cross domain design for IoT systems based on OCM</li> <li>• Understands the connections between cloud security and IoT security</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on IoT security and operating systems, tool tutorials</li> <li>• Practical Skills: Projects, Labs &amp; Exercises, continuation of the small project with an IoT device</li> <li>• Scientific Competences: own research on IoT security issues</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>MOD-E09 - Smart Home &amp; Smart Building &amp; Smart City</p> <p>MOD-E10 - Edge Computing</p> <p>Input from:</p> <p>MOD1-03 – Digital Systems 1</p>
<b>10</b>	<p><b>References</b></p> <p>CERP-IoT: Vision and Challenges for realizing the Internet of Things, European Union, 2010</p>



J. Clarke, N. Suri, A. Sharma: Trust and security of the Internet of Things (IoT), BIC Discussion Paper, Coordinated by Waterford Institute of Technology, Cork Road, Waterford, Ireland, 2012

IoT-A: Internet-of-Things-Architecture, FP7 Project Home Page, Retrieved from <http://www.iot-a.eu/public/front-page> , last accessed June 06, 2013

Gausemeier, J., Steffen, D., Donoth, J., Kahl, S.: Conceptual Design of Modularized Advanced Mechatronic Systems. 17th International Conference on Engineering Design (ICED`09), August 24-27, 2009, Stanford, CA, USA, 2009

Lückel, J.; Hestermeyer, T.; Liu-Henke, X.: Generalization of the Cascade Principle in View of a Structured Form of Mechatronic Systems. 2001 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM 2001), Villa Olmo; Como, Italy, 2001

<b>Scientific &amp; Transversal Skills 2 (MOD2-04)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48090/91	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Scientific & Transversal Skills 2	<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students	
<b>2</b>	<b>Course Description</b> <p>The course is intended for adding specific scientific and transversal skills to the curriculum. It is intended to prepare students for both a scientific path in the third and fourth semester or for a more application oriented path with internships and theses in industry. Students select compact courses worth 6 ECTS in total on topics relevant for the further study programme. The selection of courses is need based and will be assessed by interviewing the students, by doing tests (where necessary) and by consulting.</p>				
<b>3</b>	<b>Course Structure</b> <p>In the initial set up of the master a selection of 8 compact courses are offered. More can be added according to the analysis of the needs of actual students:</p> <ol style="list-style-type: none"> <li>1. Compact Course on Business Models and Business Cases</li> <li>2. IT Tools for Projects (Redmine, Jira, Confluence)</li> <li>3. Mini Projects (Group Projects, with other Master's programmes)</li> <li>4. Research Methods and Tools – part B (RMT-B) (Research Design, Tools, Databases, Publishing)</li> <li>5. International Negotiation &amp; Conflict Management (English)</li> <li>6. Engineering Communication 1 (German A2, or other foreign language for Germans)</li> </ol>				
<b>4</b>	<b>Application Focus</b> <p>Depending on choice of courses</p>				
<b>5</b>	<b>Scientific Focus</b> <p>Depending on choice of courses</p>				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course:</li> <li>• Assessment of the course: Depending on choice of courses</li> </ul>				

	<ul style="list-style-type: none"> <li>Teaching staff: Prof. Dr. Rolf Schuster, PhD students of IDiAL for compact courses, external Professor from partner university for “Research Methods and Tools – part B (RMT-B)”, language trainers and coaches e.g. from Auslandsgesellschaft</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>Knows the foundations of each topic at least up to bachelor knowledge</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>Can apply the knowledge in the upcoming master courses</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>Can assess the gaps in own knowledge</li> <li>Can use a variety of tools, online-courses, tutorials to close the gap in own responsibility</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <p>Compact courses will follow a similar structure:</p> <ul style="list-style-type: none"> <li>1 day introduction at the end of the first semester, mini-tests to assess the prior knowledge and to define the gap. Definition of the training need and selection of trainings and exercises</li> <li>0,5 day assessment and tutorial in the week before summer school</li> <li>Tutorials on each Friday throughout the whole semester</li> <li>Access to e-learning modules and MOOCs for each topic</li> <li>Literature recommendations and provision of exercises</li> <li>Submission of homework for assessment and advice by tutors</li> </ul> <p>Language and communication trainings will be done on a weekly basis, e.g. Monday afternoon + evening (in connection with external trainers, e.g. from Auslandsgesellschaft)</p>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>Depending on choice of courses</p> <p>Input from:</p> <p>MOD1-05 – Scientific &amp; Transversal Skills 1</p>
<b>10</b>	<p><b>References</b></p> <p>Depending on choice of courses</p>

<b>Research Project (Thesis) (MOD3-03)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48190/91	540 h	18	3	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Research Project (Thesis)		<b>Contact hours</b> 0 h	<b>Self-Study</b> 540 h	<b>Planned Group Size</b> individual participation
<b>2</b>	<b>Course Description</b> The research project is intended to introduce students into scientific research work in a bigger context. Students will participate in one of the ongoing research projects. They will contribute with an own sub project. The starting point is the definition of the research questions they want to answer and the selection of the appropriate methodology. The students will plan and execute their project independently with regular review and consulting. They will summarize their finding in a research project thesis (project report). The research project will be a preparation for further work on the master thesis. The intention of the research project is to familiarize with the research methodology in a certain scientific field and to formulate the scientific state of the art and the research questions. The student proves the ability to execute own and independent research on master level and with a certain complexity.				
<b>3</b>	<b>Course Structure</b> Students will select a topic from one of the ongoing projects or an industry case in Digitalization, Software Engineering and Digital Systems. They will get individual consulting and feedback. During the semester the students will write a project thesis and present it in a colloquium at the end of the semester.  Excellent results are intended to be published and presented (oral or poster) at a conference (can be done in connection with the master thesis, too).				
<b>4</b>	<b>Application Focus</b> The Research Project (Thesis) is done in connection with a research project. It is recommended to do the project and the thesis in connection with an internship/student job in industry or within a research project at a university or research institute, e.g. IDiAL.				
<b>5</b>	<b>Scientific Focus</b> The Research Project (Thesis) is embedded into the scientific activities of the university, especially within the research institutes IDiAL and IKT.				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 18</li> <li>• Hours of study in total: 540</li> <li>• Weekly hours per semester: <ul style="list-style-type: none"> <li>- Contact hours: 0</li> <li>- Self-Study hours: 540</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – winter semester</li> <li>• Maximal capacity: individual participation</li> <li>• Course admittance prerequisites:</li> <li>• Skills trained in this course:</li> </ul>				

	<ul style="list-style-type: none"> <li>• Assessment of the course: Project thesis about own research in an ongoing project as individual homework + presentation in colloquium (100%)</li> <li>• Teaching staff: all professors</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows state of the art in a certain scientific field</li> <li>• Knows open research questions in this field</li> <li>• Knows relevant literature</li> <li>• Knows methodology and tools to execute project</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can define and plan an own research project</li> <li>• Can apply appropriate research methodology</li> <li>• Can create own research findings</li> <li>• Can describe project execution, methodology and findings in a scientific report</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can run an own more complex scientific research project</li> <li>• Masters uncertainty and unknown topics in new area</li> <li>• Can present and defend results (in colloquium or at a conference)</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <p>Project Theses are done with individual supervision:</p> <ul style="list-style-type: none"> <li>• Project Work, in a scientific project or within an internship in industry</li> <li>• Writing of a scientific report</li> <li>• Presentations to communicate and discuss the findings</li> <li>• E-learning course on scientific work and scientific writing</li> <li>• Individual review and feedback on papers and presentations</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>P – Master Thesis + Colloquium</p> <p>Input from:</p> <p>none</p>
<b>10</b>	<p><b>References</b></p> <p>According to topic</p>

<b>Master Thesis + Colloquium</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
	900 h	30	4	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Master Thesis	<b>Contact hours</b> 0 h (individual consulting and colloquium)	<b>Self-Study</b> 900 h	<b>Planned Group Size</b> individual participation	
<b>2</b>	<b>Course Description</b> <p>The research project is intended to introduce students into scientific research work in a bigger context. Students will participate in one of the ongoing research projects. They will contribute with an own sub project. The starting point is the definition of the research questions they want to answer and the selection of the appropriate methodology. The students will plan and execute their project independently with regular review and consulting. They will summarize their finding in a research project thesis (project report). The research project will be a preparation for further work on the master thesis. The intention of the research project is to familiarize with the research methodology in a certain scientific field and to formulate the scientific state of the art and the research questions. The student proves the ability to execute own and independent research on master level and with a certain complexity.</p>				
<b>3</b>	<b>Course Structure</b> <p>Students will select a topic from one of the ongoing projects or an industry case in Digitalisation, Software Engineering and Digital Systems. They will get individual consulting and feedback. During the semester the students will write a project thesis and present it in a colloquium at the end of the semester.</p> <p>Excellent results are intended to be published and presented (oral or poster) at a conference (can be done in connection with the master thesis, too).</p>				
<b>4</b>	<b>Application Focus</b> <p>The Master thesis is done in connection with a research project. It is recommended to do the project and the thesis in connection with an internship/student job in industry or within a research project at a university or research institute, e.g. IDiAL.</p>				
<b>5</b>	<b>Scientific Focus</b> <p>The Master thesis is embedded into the scientific activities of the university, especially within the research institutes IDiAL and IKT.</p>				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 30</li> <li>• Hours of study in total: 900</li> <li>• Weekly hours per semester: only colloquium <ul style="list-style-type: none"> <li>- Contact hours: 0 (individual consulting and colloquium)</li> <li>- Self-Study hours: 900</li> </ul> </li> <li>• Course characteristics: compulsory</li> <li>• Course frequency: every year – summer semester</li> <li>• Maximal capacity: individual participation</li> <li>• Course admittance prerequisites: only one module from semester 1 – 3 open</li> </ul>				

	<ul style="list-style-type: none"> <li>• Skills trained in this course:</li> <li>• Assessment of the course: Master thesis about own research in an ongoing project as individual homework + presentation in colloquium (100%)</li> <li>• Teaching staff: all professors</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows state of the art in a certain scientific field</li> <li>• Knows open research questions in this field</li> <li>• Knows relevant literature</li> <li>• Knows methodology and tools to execute project</li> <li>• Knows how to document new findings according to scientific standards</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can define and plan an own research project</li> <li>• Can apply appropriate research methodology</li> <li>• Can create own research findings</li> <li>• Can describe state of the art, methodology and findings in a scientific report</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can compare own findings with state of the art and do a critical discussion</li> <li>• Can run an own scientific research project and create new findings</li> <li>• Masters uncertainty and unknown topics in new area</li> <li>• Can present and defend results (in colloquium or at a conference)</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <p>Project Theses are done with individual supervision:</p> <ul style="list-style-type: none"> <li>• Project Work, in a scientific project or within an internship in industry</li> <li>• Writing of a scientific report</li> <li>• Presentations to communicate and discuss the findings</li> <li>• E-learning course on scientific work and scientific writing</li> <li>• Individual review and feedback on papers and presentations</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>None – can be based on research project thesis</p>
<b>10</b>	<p><b>References</b></p> <p>According to topic</p>

## Attachment 2: Catalogue of Compulsory Elective Modules

Catalogue of Compulsory Module (Electives 1, 2 and 3)*						
Module	module examination	mod-nr/ exam-nr	student workload			ECTS-Punkte
			contact hours		self-study (hrs)	
			SWS <sup>1</sup>	hours		
Software Engineering Project	MOD-E01	48201	4	60	120	6
Requirements Engineering	MOD-E02	46910	4	60	120	6
Human Centered Digitalization	MOD-E03	48202	4	60	120	6
Formal Methods	MOD-E04	48203	4	60	120	6
Information Processing and Data Analytics	MOD-E05	48207	4	60	120	6
Research Seminar	MOD-E06	48206	4	60	120	6
Digital Business Ecosystems	MOD-E07	48204	4	60	120	6
Managing Digital Change	MOD-E08	48208	4	60	120	6
Smart Home & Smart Building & Smart City	MOD-E09	48209	4	60	120	6
Edge Computing	MOD-E10	48210	4	60	120	6
Module(s) from cooperating institutions						
Module(s) from study courses of the home institution**						

\* From the Catalogue of Compulsory Electives a minimum of 3 modules must be completed with an examination (MOD2-05, MOD3-01 and MOD3-02). More than 18 credit points may be obtained which will be marked in the certificate.

\*\* If compulsory elective modules of the Ruhr Master School (RMS) are part of the course programmes of Dortmund University of Applied Sciences and Arts (Fachhochschule Dortmund), students must complete the examinations within their own course programme.

Upon application, modules of the course programmes participating in the RMS may be elected.



## Compulsory Elective

<b>Software Engineering Project (MOD-E01)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48201	180 h	6	3	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Software Engineering Project	<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students	
<b>2</b>	<b>Course Description</b> <p>The aim of this course is to provide students with theoretical and practical experience in software engineering. Therefore, the students work in teams on real world tasks in cooperation with industry partners. The course focuses on software architecture and software engineering principles that are the foundation for implementing software systems. During the course, the students need to apply agile methods to their project and team for a dynamic software engineering approach. Evaluating software tools for their project is another task within this course, e.g. continuous delivery, IDEs. In summary, the students implement the complete life cycle from requirements engineering to design over the development of a software system.</p>				
<b>3</b>	<b>Course Structure</b> <p>The course is training software engineering skills by applying the following competences (from previous modules) within a realistic project (e.g. industry case):</p> <ul style="list-style-type: none"> <li>• Object oriented modeling and design</li> <li>• Architecture Design (Patterns, Frameworks, Libraries)</li> <li>• Software Testing</li> <li>• Tools <ul style="list-style-type: none"> <li>○ Version control systems (Git, SVN, Mercurial SCM)</li> <li>○ Code management</li> <li>○ Ticket systems and bug tracker</li> <li>○ (Continuous) integration and release management</li> <li>○ Documentation</li> </ul> </li> <li>• Processes <ul style="list-style-type: none"> <li>○ Classical software development</li> <li>○ Agile software development (Scrum)</li> </ul> </li> <li>• Requirements Engineering</li> <li>• Project management, project planning, quality management</li> </ul>				
<b>4</b>	<b>Application Focus</b> <p>Within a block-week, the students realize a whole software project starting from requirements engineering to design and development. The whole process is accompanied by an industry partner and takes place in the User Innovation Center.</p>				
<b>5</b>	<b>Scientific Focus</b> <ul style="list-style-type: none"> <li>• Scientific documentation of the content used in the project as well as the related and applied principles</li> </ul>				

	<ul style="list-style-type: none"> <li>• Consideration of scientific sources/papers from the Requirements Engineering and Software Engineering</li> <li>• The documentation of a scientific nature is also an assessment basis for the overall grade of this course</li> </ul>
<b>6</b>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4             <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - winter semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: MOD1-01 Innovation Driven Software Engineering, MOD1-02 Software Architectures, MOD1-04 R&amp;D Project Management</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competences</li> <li>• Assessment of the course: Practical Skills (50%): realizing a real-world project within the User Innovation Center during a block week and Scientific Competences (50%): written paper (literature review, reflection of project with current research, approx. 25 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>•</li> <li>• Teaching staff: Prof. Dr. Sabine Sachweh, external lecturers from industry and/or partner universities, PhD students from IDiAL</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Students know modeling tools for software design</li> <li>• Students know concepts and processes for agile software development</li> <li>• Students know how to create test suites for automated software testing</li> <li>• Students know how to use typically used tools in the software engineering process</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Students can apply processes and methods to specific project needs</li> <li>• Students can evaluate and use tools for developing software systems in a team</li> <li>• Students can use tools to support the development process in a team</li> <li>• Students can use tools to improve software quality</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss and defend results in topics related to the lecture content</li> <li>• Can work in a team on scientific topics</li> <li>• Can understand lecture related content and translates between different domains</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: lectures on requirements engineering</li> <li>• Practical Skills: requirements analysis of a project with DOORS, group work to train concepts and methods, to develop skills and to work on case studies</li> <li>• Scientific Competences: research paper on literature review about RE topic</li> </ul>

<b>9</b>	<b>Course mapping</b>  Input for:  none  Input from:  MOD1-01 Innovation Driven Software Engineering  MOD1-02 Software Architectures  MOD1-04 R&D Project Management  MOD2-02 Software-intensive Solutions
<b>10</b>	<b>References</b>  <a href="https://www.pearson-studium.de/software-engineering-global-edition.html">https://www.pearson-studium.de/software-engineering-global-edition.html</a> (Ian Sommerville, ISBN 978-1-2920-9614-8)  <a href="http://eu.wiley.com/WileyCDA/WileyTitle/productCd-EHEP000908.html">http://eu.wiley.com/WileyCDA/WileyTitle/productCd-EHEP000908.html</a> (Hans van Vliet)  Domain Driven Design (Eric Evan)  Design Pattern (Gang of Four; ISBN 978-0201633610)  ( <a href="https://www2.swc.rwth-aachen.de/se_buch/">https://www2.swc.rwth-aachen.de/se_buch/</a> (deutsch; Horst Lichter, Jochen Ludwig))  <a href="http://www.hanser-fachbuch.de/buch/UML+2+glasklar/9783446430570">http://www.hanser-fachbuch.de/buch/UML+2+glasklar/9783446430570</a> (deutsch; ISBN 978-3-446-43057-0)

## Compulsory Elective

<b>Requirements Engineering (MOD-E02)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
46910	180 h	6	3	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Requirements Engineering	<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students	
<b>2</b>	<b>Course Description</b> Requirements engineering (RE) is the very first activity in software, systems, and service development. Deriving a comprehensive set of requirements is a mandatory and critical task in the early phase of the systems engineering design flow. Requirements are the starting point and main angle for design, verification & validation, and for the test and integration of systems. Configuration and change request management are connected with RE. Defining requirements and dealing with requirements in a structured way is still a major area for research on tools and methodologies – especially for large and complex mechatronic systems. In this module, students will get specific knowledge about the state of the art and the main future challenges in RE.				
<b>3</b>	<b>Course Structure</b> <ol style="list-style-type: none"> <li>1. Introduction (What is a requirement?, problem vs. solution)</li> <li>2. Frameworks (e.g. Jackson's WRSPM Modell)</li> <li>3. Requirements Engineering Process (stakeholder, activities)</li> <li>4. System and system context</li> <li>5. Elicitation of requirements (techniques and supporting activities, Kano model)</li> <li>6. Textual requirements documents</li> <li>7. Requirements modeling (e.g. goal-oriented modeling, requirements patterns)</li> <li>8. Non-functional requirements</li> <li>9. Validation of requirements</li> <li>10. Requirements Management (attributes, prioritization, traceability, change management, RE tools, CMMI, ReqIF exchange format)</li> <li>11. Software product lines and variability management</li> </ol>				
<b>4</b>	<b>Application Focus</b> Requirements analysis of an industrial case with DOORS				
<b>5</b>	<b>Scientific Focus</b> Paper with literature review/state-of-the-art in RE				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4               <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - winter semester</li> </ul>				

	<ul style="list-style-type: none"> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competences</li> <li>• Assessment of the course: Theoretical knowledge: Oral Exam at the end of the course (30%), Practical Skills: Individual programming task (40%): DOORS demonstration and presentation of example and Scientific Competences: Paper/essay on literature review about recent research as individual homework (30%)</li> <li>• Teaching staff: Prof. Dr. Erik Kamsties, PhD students from IDiAL</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows frameworks and models for RE</li> <li>• Knows relevant RE processes and interfaces to other processes</li> <li>• Knows concepts and recent research on product line and variability management</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can model requirements with RE tools</li> <li>• Can set up and integrate RE tools into tool chains and design flows</li> <li>• Can derive requirements in a structured and comprehensive way</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Understands the importance of RE in the early project phase</li> <li>• Can set up and lead RE in a cross domain team</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: lectures on requirements engineering</li> <li>• Practical Skills: requirements analysis of a project with DOORS, group work to train concepts and methods, to develop skills and to work on case studies</li> <li>• Scientific Competences: research paper on literature review about RE topic</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for: none</p> <p>Input from: R&amp;D Project Management (MOD1-04)</p>
<b>10</b>	<p><b>References</b></p> <p>Pohl, K.; Requirements Engineering: Fundamentals, Principles, and Techniques, Springer 2010.</p> <p>Robertson, S. and Robertson, J.; Mastering the Requirements Process: Getting Requirements Right, Addison-Wesley, 2012.</p> <p>van Lamsweerde, A.; Requirements Engineering: From System Goals to UML Models to Software Specifications, John Wiley &amp; Sons, 2009.</p>

## Compulsory Elective

<b>Human Centered Digitalization (MOD-E03)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48202	180 h	6	3	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Human Centered Digitalization		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<p><b>Course Description</b></p> <p>Digitalization in private and professional domains is influencing intensely and sometimes even revolutionizing people's life, the way they interact with systems, the way they interact between each other, the way a society changes. Within this course those influences will be addressed from two different viewpoints. From an analytical perspective, former and current developments and their influences will be analyzed and then projected on future trends. From a constructive perspective, those potential influences of e.g. a product or service currently in development will be taken into account to shape the prospective solution.</p>				
<b>3</b>	<p><b>Course Structure</b></p> <ul style="list-style-type: none"> <li>• Basic Overview "Computer Science &amp; Society"</li> <li>• Ethics in computer science</li> <li>• Digital media and art</li> <li>• Surveillance and privacy</li> <li>• Artificial Intelligence and responsibility</li> <li>• Case Studies "Disruptive Changes by Information Technology"</li> <li>• Digitalization of work life &amp; work environments, processes, products and services</li> <li>• Evaluation of impacts (personal, environment, society)</li> </ul>				
<b>4</b>	<p><b>Application Focus</b></p> <p>Case Studies "Disruptive Changes by Information Technology"</p> <p>Involvement in projects: Analyzing impacts and potentials for news products and services</p>				
<b>5</b>	<p><b>Scientific Focus</b></p> <p>(Pre-)Studies &amp; surveys about socioeconomic impacts of digitalization</p> <p>Paper with literature review/state-of-the-art</p>				
<b>6</b>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - winter semester</li> <li>• Maximal capacity: 25 students</li> </ul>				

	<ul style="list-style-type: none"> <li>• Course admittance prerequisites: Innovation Driven Software Engineering (MOD1-01), R&amp;D Project Management (MOD1-04)</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competences</li> <li>• Assessment of the course: Practical Skills (50%): Group work and/or individual task, case studies and projects =&gt; demonstration/presentation of the result an Scientific Competences (50%): written paper (literature review, study report or survey, approx. 25 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>• Teaching staff: Prof. Dr. Christian Reimann, International experts from industry and academia, PhD students from IDiAL</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows relevant theoretical foundations, area: computer science and society</li> <li>• Know methodical background of case studies and surveys</li> <li>• Is aware of critical limitations of methods for evaluating impact</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can analyze the impact of changes in information technology on individuals, environment and society, based upon a given past scenario</li> <li>• Can evaluate, analyze (and within limits predict) the impact of new products/services on individuals, environment and society, during the concept and development phase</li> <li>• Can conduct methodologically structured evaluations (e.g. field observation, lab tests) and surveys</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss impacts of changes in information technology on individuals, environment and society with experts</li> <li>• Can advise during product/service development potential impacts of product/service structure/features on individuals, environment and society</li> <li>• Understands scientific publication in the related areas</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on formal methods, tool tutorials</li> <li>• Practical Skills: Projects with MechatronicUML</li> <li>• Scientific Competences: literature review and synthesis into a paper</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>R&amp;D project &amp; Thesis</p> <p>Input from:</p> <p>Innovation Driven Software Engineering (MOD1-01)</p> <p>R&amp;D Project Management (MOD1-04)</p> <p>Usability Engineering (MOD2-01)</p>
<b>10</b>	<p><b>References</b></p> <p>Changing conference proceedings and journals, e.g.</p> <p>ICT and Society: 11th IFIP TC 9 International Conference on Human Choice and Computers, HCC11 2014, Turku, Finland, July 30 - August 1, 2014, Proceedings 431 IFIP Advances in</p>

Information and Communication Technology, Springer, 2014, ISBN 3662442086,  
9783662442081

eHealth: Legal, Ethical and Governance Challenges, Carlisle George, Diane  
Whitehouse, Penny Duquenoy, Springer Science & Business Media, 2012, ISBN 3642224741,  
9783642224744

An Ethical Global Information Society: Culture and democracy revisited  
IFIP Advances in Information and Communication Technology, Jacques J. Berleur, Diane  
Whitehouse, Springer, 2013, ISBN 0387353275, 9780387353272

Human Choice and Computers: Issues of Choice and Quality of Life in the Information Society  
Band 98 von IFIP Advances in Information and Communication Technology, Klaus  
Brunnstein, Jacques Berleur, Springer, 2013, ISBN 0387356096, 9780387356099



## Compulsory Elective

<b>Formal Methods (MOD-E04)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48203	180 h	6	3	winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Formal Methods		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<p><b>Course Description</b></p> <p>Software has become the driving force in the development of self-optimizing systems. Such systems include hard-realtime coordination, which is realized by software, at the network level between distributed components as well as controllers which are more and more implemented by software. The communication goes beyond the use of system and environmental data from controllers. If necessary, complex status information about appropriate protocols and communication channels are exchanged, which themselves can massively influence the underlying behavior of the individual components. This development leads to extremely complex hybrid (discrete / continuous) software. In addition, self-optimizing systems are often used in safety-critical environments. This enforces the use of formal verification techniques to ensure the correctness of specified properties.</p> <p>In the course concepts and methods for the modelling and verification of these systems are introduced and formally described. In order to enable an efficient verification for such systems, techniques like abstraction, decomposition as well as rule-based modelling are introduced. Here, these non-orthogonal techniques are skillfully combined. One aim is to handle all models specified by all different domains. The presented approach for the model-based verification of systems is massively characterized by the integration of efficient verification techniques for the different domains, based on their domain specific model-based knowledge</p>				
<b>3</b>	<p><b>Course Structure</b></p> <ol style="list-style-type: none"> <li>1. Motivation: <ol style="list-style-type: none"> <li>a. What are Formal Methods?</li> <li>b. Why should we use Formal Methods?</li> <li>c. When in the overall development process should we use Formal Methods?</li> </ol> </li> <li>2. Model Checking</li> <li>3. Theorem Proving</li> <li>4. Testing</li> <li>5. Formal Verification in practice: The MechatronicUML Approach</li> <li>6. Recent Research: literature review</li> <li>7. AMALTHEA Methodology and Tool Chain</li> </ol>				
<b>4</b>	<p><b>Application Focus</b></p> <p>AMALTHEA tool chain – will be used to integrate formal verification tools</p> <p>Rail Cab (Uni Paderborn) – will be used as an example</p>				
<b>5</b>	<p><b>Scientific Focus</b></p>				

	Paper with literature review/state-of-the-art in formal verification
<b>6</b>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4             <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - winter semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge and scientific competences</li> <li>• Assessment of the course: Oral Exam at the end of the course (50%) and individual research paper and presentation (50%)</li> <li>• Teaching staff: Prof. Dr. Martin Hirsch</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows methodology of formal verification</li> <li>• Knows relevant theoretical background</li> <li>• Knows specific requirements</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can methods on use case</li> <li>• Can model verification artefacts (e.g. properties)</li> <li>• Can use MechatronicUML approach and tools</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can research on state of the art and theoretical background</li> <li>• Can demonstrate and discuss results in group</li> <li>• Can structure scientific field and get overview</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on formal methods, tool tutorials</li> <li>• Practical Skills: Projects with MechatronicUML</li> <li>• Scientific Competences: literature review and synthesis into a paper</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for: None</p> <p>Input from: None</p>
<b>10</b>	<p><b>References</b></p> <p>Spivey: The Z Reference Manual (<a href="http://spivey.oriel.ox.ac.uk/mike/zrm/zrm.pdf">http://spivey.oriel.ox.ac.uk/mike/zrm/zrm.pdf</a>)</p> <p>E. Clarke et al.: Model Checking, MIT Press</p> <p>T. Fischer, J. Niere, L. Torunski, and A. Zündorf: Story Diagrams: A new Graph Rewrite Language based on the Unified Modeling Language. In Proc. of the 6th International Workshop on Theory and Application of Graph Transformation (TAGT), Paderborn, Germany, 1998</p>

W. Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien. Vieweg+Teubner, 2010

J. Bengtsson, W. Yi: Timed Automata: Semantics, Algorithms and Tools. In Lecture Notes on Concurrency and Petri Nets. W. Reisig and G. Rozenberg (eds.), LNCS 3098, Springer-Verlag, 2004

T. Eckart, C. Heinzemann, S. Henkler, M. Hirsch, C. Priesterjahn, W. Schäfer: Modeling and verifying dynamic communication structures based on graph transformations. Computer Science - Research and Development 28(1): S. 3-22, Feb. 2013

M. Hirsch: Modell-basierte Verifikation von vernetzten mechatronischen Systemen. Dissertation, Logos Verlag, 2008

## Compulsory Elective

<b>Information Processing and Data Analytics (MOD-E05)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48207	180 h	6	3	winter semester	1 Semester
<b>1</b>	<b>Course Title</b>		<b>Contact hours</b>	<b>Self-Study</b>	<b>Planned Group Size</b>
	Information Processing and Data Analytics		4 SWS / 60 h	120 h	25 students
<b>2</b>	<b>Course Description</b>				
	Modern management is based on facts and on data. Dealing with data, analyzing data and deriving conclusions and decisions from data is crucial for management. The module is developing the topics of information processing and data analytics along a case study.				
<b>3</b>	<b>Course Structure</b>				
	<p><i>1. Information processing and data collection</i></p> <p>1.1 Development of indicator systems 1.2 Design of data collection experiments with online tools 1.3 IT tools for data collection 1.4 Advanced MS Excel</p> <p><i>2. Data bases and data warehouses</i></p> <p>2.1 Introduction to databases, SQL 2.2 Data warehouse systems 2.3 Cloud based systems 2.3 Analysis of Case Studies</p> <p><i>3. Data analytics</i></p> <p>3.1 Data refinement 3.2 Data analytics and business intelligence 3.3 Probabilistic methods 3.4 Artificial intelligence and learning (introduction to IBM Watson)</p>				
<b>4</b>	<b>Application Focus</b>				
	<p>Students will be guided through a case study project where they set up a small experiment for data collection, data storage and query and data processing for an example case. They form teams and set up IT tools.</p> <p>Trainings: students attend an Excel training and an IBM Watson training</p>				
<b>5</b>	<b>Scientific Focus</b>				
	Students work in teams and set up data analytics experiments and tools for their respective case study project.				
<b>6</b>	<b>Parameters</b>				
	<ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4</li> </ul>				

	<ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - winter semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competences</li> <li>• Assessment of the course: Theoretical knowledge (30%): Written or oral Exam at the end of the course, Practical Skills (50%): contributions within case study project (team presentation) and Scientific Competences (20%): written paper (report, approx. 10 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund)</li> <li>• Teaching staff: Prof. Dr. Christian Reimann, PhD students from IDiAL, guest lecturers from partner universities (e.g.. FH Krems)</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge Student can</p> <ul style="list-style-type: none"> <li>• explain the basic characteristics of data and data collection</li> <li>• explain advanced functionality of Excel</li> <li>• explain database and data warehouse concepts</li> <li>• explain the core concepts of data analytics and business intelligence</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• develop data collection experiments with online tools</li> <li>• apply MS Excel for data analytics</li> <li>• set up and use simple SQL databases</li> <li>• set up and use tools for statistical data analysis</li> <li>• use IBM Watson for AI experiments</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• students train to do surveys with people from different cultural backgrounds</li> <li>• in discussion students develop a critical attitude to data based decision making and to issues like privacy and data protection</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: (video-)lectures introducing concepts, methods and tools, tool tutorials</li> <li>• Practical Skills: group work in the case study project to practice concepts and methods, to develop skills and to work on case studies</li> <li>• Scientific Competences: presentations to communicate results and do a scientific discussion and reflection</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for: none</p> <p>Input from: none</p>
<b>10</b>	<p><b>References</b></p>

Ralph Kimball, Margy Ross, Warren Thornthwaite, Joy Mundy, Bob Becker: The Kimball Group Reader: Relentlessly Practical Tools for Data Warehousing and Business Intelligence, John Wiley & Sons 2010, ISBN 9780470563106.

Scott Cameron: Microsoft® SQL Server® 2008 Analysis Services Step by Step, Microsoft Press 2000

## Compulsory Elective

<b>Research Seminar (MOD-E06)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48206	180 h	6	2 + 3	summer and winter semester	1 Semester
<b>1</b>	<b>Course Title</b> Research Seminar		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> individual
<b>2</b>	<p><b>Course Description</b></p> <p>The Research Seminar is intended to introduce students into scientific writing, literature review and into discussion of research questions in a scientific auditory. Students will write a scientific report or essay on a recent research topic from one of the ongoing projects. The seminar will be a preparation for further work on the research project thesis and the master thesis. The intention of the seminar is to explore a certain scientific field and to formulate the scientific state of the art and the open research questions. A motivation for students will be the possibility to publish and present excellent papers at a small conference.</p>				
<b>3</b>	<p><b>Course Structure</b></p> <p>Students will select a topic from one of the ongoing projects in Digitalization, Software Engineering and Digital Systems. They will get individual consulting and feedback. During the semester the students will write a paper/report and present it in a colloquium at the end of the semester.</p> <p>The research seminar is recommended for students who want to follow a more scientific path within the Master's program. It lays foundations for the scientific quality of the later Research Project Thesis and Master Thesis. Excellent papers will be published and presented (oral or poster) at the Dortmund International Research Conference at FH Dortmund.</p>				
<b>4</b>	<p><b>Application Focus</b></p> <p>The research seminar has a mainly scientific focus.</p>				
<b>5</b>	<p><b>Scientific Focus</b></p> <p>The Research Seminar is embedded into the scientific activities of the university, especially within the research institutes IDiAL and IKT.</p>				
<b>6</b>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> </ul>				

	<ul style="list-style-type: none"> <li>• Course characteristics: elective</li> <li>• Course frequency: summer and winter semester</li> <li>• Maximal capacity: individual</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical, practical and scientific skills and competences</li> <li>• Assessment of the course: Report as individual homework + presentation in colloquium (100%)</li> <li>• Teaching staff: all professors</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows state of the art in a certain scientific field</li> <li>• Knows open research questions in this field</li> <li>• Knows relevant literature</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can analyze scientific literature based on a comprehensive review</li> <li>• Can write a paper/report according to scientific standards</li> <li>• Can synthesize findings in own words</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can run an own small scientific research project</li> <li>• Can present and defend results at a conference</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <p>Research seminars are done with individual supervision:</p> <ul style="list-style-type: none"> <li>• Writing of a scientific report</li> <li>• Presentations to communicate and discuss the findings</li> <li>• Individual review and feedback on papers and presentations</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for:</p> <ul style="list-style-type: none"> <li>• MOD3-03 – Research Project (Thesis) + Colloquium</li> <li>• P – Master Thesis + Colloquium</li> </ul> <p>Input from:</p> <p>None</p>
<b>10</b>	<p><b>References</b></p> <p>German and European Research Agendas, recent research papers</p>



<b>Digital Business Ecosystems (MOD-E07)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48204	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Digital Business Ecosystems		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b> The term “Digital Business Ecosystem” (DBE) emerged beginning of the 2000s by adding “Digital” to Moore’s (1996) “Business Ecosystem” concept. The analysis, structuring, development and management of DBEs combine socio-economic concepts, ICT and biological concepts. Students will learn to understand, to analyse, to evaluate and to develop DBE for different application scenarios.				
<b>3</b>	<b>Course Structure</b>  <ol style="list-style-type: none"> <li>1. Cybernetics and systems view               <ol style="list-style-type: none"> <li>1.1 Biological Systems</li> <li>1.2 Cybernetics and Systems theory, social theories</li> <li>1.3 System models, e.g. Ropohl, Systems engineering</li> <li>1.4 Evolutionary and self-organizing systems</li> </ol> </li> <li>2. Socio-economic view               <ol style="list-style-type: none"> <li>2.1 Business Ecosystems</li> <li>2.2 Business processes, business models and value chains</li> <li>2.3 Innovation, competition and dynamics in business ecosystems</li> <li>2.3 Analysis of Case Studies</li> </ol> </li> <li>3. ICT view               <ol style="list-style-type: none"> <li>3.1 Information supply chain</li> <li>3.2 ICT architectures and tools for DBEs</li> <li>3.3 Efficiency and effectivity for DBEs</li> <li>3.4 Analysis of Case Studies</li> </ol> </li> </ol>				
<b>4</b>	<b>Application Focus</b> Students will be guided through a case study project where they set up a small DBE for an example case. They form teams and set up IT tools.				
<b>5</b>	<b>Scientific Focus</b> Students will do literature review on DBE and do scientific discussion and reflections				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4               <ul style="list-style-type: none"> <li>– Contact hours: 60</li> <li>– Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year – summer semester</li> </ul>				

	<ul style="list-style-type: none"> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical knowledge, practical skills and scientific competencies</li> <li>• Assessment of the course: Theoretical knowledge: Oral or written exam at the end of the course (50%) and Practical Skills: contributions within case study project (team presentation) =&gt; demonstration of the result (50%)</li> <li>• Teaching staff: Prof. Dr. Carsten Wolff, guest lecturers from partner universities (e.g. FH Krems)</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge Students can</p> <ul style="list-style-type: none"> <li>• explain the basics of cybernetics and systems theory</li> <li>• explain and compare digital business models</li> <li>• explain methods and tools for information supply chains</li> <li>• explain the core concepts of DBEs</li> </ul> <p>7.2 Skills Students are able to</p> <ul style="list-style-type: none"> <li>• analyze and develop value chains and information supply chains</li> <li>• apply ICT tools for information supply chains</li> <li>• develop tailored processes for DBEs</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Students train to develop and discuss concepts in teams</li> <li>• Students work in teams and set up DBE environments for their respective case study project</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: Lectures introducing concepts, methods and tools</li> <li>• Practical Skills: Group work in the case study project to practice concepts and methods, to develop skills and to work on case studies</li> <li>• Scientific Competences: Presentations to communicate results and do a scientific discussion and reflection</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for: None</p> <p>Input from: None</p>
<b>10</b>	<p><b>References</b></p>

F. Nashira, A. Nicolai, P. Dini, M.L. Louarn, L.R. Leon: Digital Business Ecosystem. European Commission, 2010, Retrieved from <http://www.digital-ecosystems.org/book/de-book2007.html>, last accessed June 06, 2013

S. Sun, J. Yen: Information Supply Chain: A Unified Framework for Information-Sharing, P. Kantor et al. (Eds.): ISI 2005, LNCS 3495, pp. 422 – 428, 2005

CERP-IoT: Vision and Challenges for realizing the Internet of Things, European Union, 2010

A. Humphreys, K. Grayson: The Intersecting Roles of Consumer and Producer: A Critical Perspective on Co-Production, Co-Creation and Prosumption, Sociology Compass 2, 2008

## Compulsory Elective

<b>Managing Digital Change (MOD-E08)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48208	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Managing Digital Change		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b>  The digital transformation is to a relevant extent a change process with a huge impact on organizations, processes, business model, the socio-economic environment and finally the affected hum beings. Managing the digital change means doing change management in a very specific context by implementing change projects. The module intends to give students a scientific insight into the relevant underlying mechanisms of the digital change process.				
<b>3</b>	<b>Course Structure</b>  <ol style="list-style-type: none"> <li>1. <i>Digital Transformation in Organisations</i> <ol style="list-style-type: none"> <li>1.1 New digitalized forms of organisation</li> <li>1.2 Business models and business relations in the digital era</li> <li>1.3 Structural resistance of organisations against digital change</li> <li>1.4 Chances and risks of digital transformation in organisations</li> </ol> </li> <li>2. <i>Socio-economic Impact of Digital Transformation</i> <ol style="list-style-type: none"> <li>2.1 Digital transformation as a socio-economic trend</li> <li>2.2 "Arbeit 4.0"</li> <li>2.3 Education and training as impact mitigation</li> <li>2.3 Analysis of Case Studies</li> </ol> </li> <li>3. <i>Sustainable Digital Transformation</i> <ol style="list-style-type: none"> <li>3.1 Stakeholder management in digital transformation projects</li> <li>3.2 Project management for digital transformation projects</li> <li>3.3 Efficiency and effectivity measurement</li> <li>3.4 Sustainability and maturity models</li> </ol> </li> </ol>				
<b>4</b>	<b>Application Focus</b>  Students will be guided through a case study project where they plan a digital transformation project for an example case. This example case will be taken preferably from a real company project. Companies can bring their digital transformation projects as a case study for a block week or summer school workshop. Students form teams to prepare the respective project and present it in a kick-off presentation to the companies.				
<b>5</b>	<b>Scientific Focus</b>				

	Literature review and analysis. Deductive own research based on the literature. Scientific reflection and discussion in the teams.
<b>6</b>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical, practical and scientific skills and competences</li> <li>• Assessment of the course: contributions within case study project (team presentation) (50%) and written paper (literature review, report or survey, approx. 25 pages) and presentation (in class or at a student conference, e.g. International Research Conference Dortmund) (50%)</li> <li>• Teaching staff: Prof. Dr. Carsten Wolff, guest lecturers from partner universities, EuroMPM</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>6.1 Knowledge</p> <ul style="list-style-type: none"> <li>• explain the basics of the digital transformation in organizations</li> <li>• explain and compare digital business models</li> <li>• explain methods and tools for change management</li> <li>• explain the core concepts of "Arbeit 4.0"</li> </ul> <p>6.2 Skills</p> <ul style="list-style-type: none"> <li>• analyze and develop digital transformation projects</li> <li>• apply change management to organizations</li> <li>• develop tailored concepts for sustainable digital transformation</li> </ul> <p>6.3 Competence - attitude</p> <ul style="list-style-type: none"> <li>• Students train to develop and discuss concepts in teams</li> <li>• They can present their results to companies and discuss in a professional context</li> <li>• Students work in teams and set up a digital transformation project for their respective case study</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• lectures introducing concepts, methods and tools, own literature reading</li> <li>• group work in the case study project to practice concepts and methods, to develop skills and to work on case studies</li> <li>• presentations to communicate results and do a scientific discussion and reflection</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for: None</p> <p>Input from: None</p>

<b>10</b>	<b>References</b>  John Hayes: The Theory and Practice of Change Management, Palgrave 4th ed. 2014, ISBN-10: 1137275340  Esther Cameron, Mike Green: Making Sense of Change Management: A Complete Guide to the Models, Tools and Techniques of Organizational Change, Kogan Page, 2015, ISBN-10: 0749472588  Joe Tidd, John Bessant: Managing Innovation: Integrating Technological, Market and Organizational Change, John Wiley & Sons, 2013  Tim Teuscher: SMEs and Digital Transformation: Are Change Management Theories Transferable?, University of Strathclyde. Dept. of Strategy and Organisation, 2015  Pearl Zhu: Change Insight: Change as an Ongoing Capability to Fuel Digital Transformation, 2016, e-book, EAN: 9781483583273  Ralf T. Kreuzer, Tim Neugebauer, Annette Pattloch: Digital Business Leadership, Springer 2017, ISBN 978-3-658-11914-0
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## Compulsory Elective

<b>Smart Home &amp; Smart Building &amp; Smart City (MOD-E09)</b>					
Code Number	Workload	Credits	Semester	Frequency	Duration
48209	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Smart Home & Smart Building & Smart City		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<p><b>Course Description</b></p> <p>The digital transformation is a major driver for the change in people's living environment. It affects the technical design of infrastructure systems, starting from people's home via larger buildings and reaching up to systems like cities or districts. It covers home automation, energy and mobility systems and assistance systems. The course introduces the trends, developments and standards from the smart home, smart building and smart city domains and put them into the context of software and IoT systems. The aim is to enable students to develop larger software systems within the given context and to integrate them with other IoT and cloud systems. Therefore, it is intended to form a domain specific view on the digital transformation.</p>				
<b>3</b>	<p><b>Course Structure</b></p> <p><i>1. Smart home</i></p> <p>1.1 Home automation 1.2 Standards and bus systems (e.g. KNX) 1.3 Energy and mobility in smart home systems 1.4 Ambient Assisted Living</p> <p><i>2. Smart Building</i></p> <p>2.1 Building Information Systems (BIM) 2.2 Safety and Security in Smart Buildings 2.3 Facility Management and Smart Building</p> <p><i>3. Smart City</i></p> <p>3.1 Smart City concepts and relevant trends 3.2 Integration of Logistics, Energy, Supplies and Mobility 3.3 Stakeholder and Citizen Involvement 3.4 Case Study: Smart City Alliance Dortmund</p>				
<b>4</b>	<p><b>Application Focus</b></p> <p>Project Smart Systems: students will set up and implement an example or a part of a Smart System (Home, Building, City). The respective case study will be taken from a recent R&amp;D project or an industry case. The result will be a demonstrator system.</p>				
<b>5</b>	<p><b>Scientific Focus</b></p> <p>Students will do a scientific evaluation of the potential of Smart Systems usage in a specific domain (e.g. transportation) based on recent scientific literature. It is intended to take issues from the Smart City Alliance Dortmund or from ruhrvalley.</p>				

<p><b>6</b></p>	<p><b>Parameters</b></p> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4             <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites: none</li> <li>• Skills trained in this course: theoretical, practical and scientific skills and competences</li> <li>• Assessment of the course: Written Exam at the end of the course (50%) and Individual programming task (50%): implementation of Smart System (or parts of it), demonstration of the results</li> <li>• Teaching staff: Prof. Dr. Ingo Kunold, staff from IKT institute, guest lecturers from joint research projects</li> </ul>
<p><b>7</b></p>	<p><b>Learning outcomes</b></p> <p>7.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows relevant home automation systems and standards</li> <li>• Know smart building concepts (e.g. BIM)</li> <li>• Knows relevant trends and projects in Smart City</li> <li>• Is aware of critical limitations, esp. safety and security issues</li> </ul> <p>7.2 Skills</p> <ul style="list-style-type: none"> <li>• Can design concepts for smart home/smart building/smart city systems</li> <li>• Can implement IoT, Cloud and SW components into such systems</li> <li>• Can apply state of the art tools and systems (e.g. KNX)</li> <li>• Can select IoT and cloud platforms according to smart home/building/city requirements</li> </ul> <p>7.3 Competence – attitude</p> <ul style="list-style-type: none"> <li>• Can discuss smart home/building/city systems with experts</li> <li>• Can lead cross domain design in this domain</li> <li>• Can contribute within the Dortmund Smart City Alliance</li> </ul>
<p><b>8</b></p>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• Theoretical knowledge: e-learning modules on Smart Systems, tool tutorials</li> <li>• Practical Skills: Projects, Labs &amp; Exercises, small project with Smart Systems</li> <li>• Scientific Competences: own research on Smart Systems</li> </ul>
<p><b>9</b></p>	<p><b>Course mapping</b></p> <p>Input for:</p> <p>None</p> <p>Input from:</p> <p>MOD1-02 Software Architectures          MOD1-03 Digital Systems 1          MOD2-02 Software-intensive Solutions          MOD2-03 Digital Systems 2</p>
<p><b>10</b></p>	<p><b>References</b></p> <p>to be defined</p>



## Compulsory Elective

<b>Edge Computing (MOD-E10)</b>					
<b>Code Number</b>	<b>Workload</b>	<b>Credits</b>	<b>Semester</b>	<b>Frequency</b>	<b>Duration</b>
48210	180 h	6	2	summer semester	1 Semester
<b>1</b>	<b>Course Title</b> Edge Computing		<b>Contact hours</b> 4 SWS / 60 h	<b>Self-Study</b> 120 h	<b>Planned Group Size</b> 25 students
<b>2</b>	<b>Course Description</b>  Internet of things (IoT) is a fundamental building block for digitization and the upcoming information society. This course provides insights into key IoT-technologies including embedded systems, networks and cloud computing. For the selection of use cases and technologies the course focuses on the area of Edge Computing. Within this area students learn about latency analysis and optimization in distributed systems. Last not least, the course offers hands on experiences with IoT and Edge Computing technologies through focused team projects and homework assignments.				
<b>3</b>	<b>Course Structure</b>  <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Real-time Embedded Systems</li> <li>3. Real-Time Networking</li> <li>4. Cloud Computing</li> <li>5. Edge Computing</li> </ol>				
<b>4</b>	<b>Application Focus</b>  Students conduct a project about Edge Sensor Fusion  Students work with Gabriel - Edge Computing Platform for Wearable Cognitive Assistance				
<b>5</b>	<b>Scientific Focus</b>  During the module recent topics from the Open Edge Computing Initiative will be discussed and papers from relevant conferences will be reviewed.				
<b>6</b>	<b>Parameters</b> <ul style="list-style-type: none"> <li>• ECTS: 6</li> <li>• Hours of study in total: 180</li> <li>• Weekly hours per semester: 4 <ul style="list-style-type: none"> <li>- Contact hours: 60</li> <li>- Self-Study hours: 120</li> </ul> </li> <li>• Course characteristics: elective</li> <li>• Course frequency: every year - summer semester</li> <li>• Maximal capacity: 25 students</li> <li>• Course admittance prerequisites:</li> <li>• Skills trained in this course: theoretical, practical and scientific skills and competences</li> </ul>				

	<ul style="list-style-type: none"> <li>• Assessment of the course: Oral Exam at the end of the course (50%) and individual programming task (50%): implementation of cloud based IoT system for a robot, demonstration of the result</li> <li>• Teaching staff: Prof. Dr. Rolf Schuster</li> </ul>
<b>7</b>	<p><b>Learning outcomes</b></p> <p>6.1 Knowledge</p> <ul style="list-style-type: none"> <li>• Knows concepts and architectures of real-time embedded systems</li> <li>• Knows key aspects of real-time networking</li> <li>• Has acquired overview of cloud computing and selected cloud platforms</li> </ul> <p>6.2 Skills</p> <ul style="list-style-type: none"> <li>• Can implement, deploy and test simple IoT-systems</li> <li>• Can set-up and utilize a cloud system</li> <li>• Can analyze the E2E latency in distributed systems</li> </ul> <p>6.3 Competence - attitude</p> <ul style="list-style-type: none"> <li>• Can design an simple IoT system for a given set of requirements</li> <li>• Can structure an IoT development project regarding function and time</li> <li>• Can propose and implement measures to reduce latency in a distributed system</li> </ul>
<b>8</b>	<p><b>Teaching and training methods</b></p> <ul style="list-style-type: none"> <li>• E-learning modules and lectures on IoT and Edge Computing</li> <li>• Small project with Eclipse IoT stack</li> <li>• Access to the Open Edge Computing Initiative and the Living Edge Labs</li> </ul>
<b>9</b>	<p><b>Course mapping</b></p> <p>Input for: None</p> <p>Input from: None</p>
<b>10</b>	<p><b>References</b></p> <p>Peter Marwedel: Embedded System Design, 2nd Edition, Springer, 2011</p> <p>Andrew S. Tanenbaum, David J. Wetherall: Computer Networks, 5th Edition, Pearson Education, 2014</p> <p>Thomas Erl, Zaigham Mahmood, Ricardo Puttini, Cloud Computing, Prentice Hall, 2013</p>