Program Documentation Master's Program Information Systems (Wirtschaftsinformatik)

Part A
Department of Informatics
Technical University of Munich

General:

- Organizational assignment: Department of Informatics
- Name: Information Systems
- Degree: Master of Science
- Regular period of study (credits): 4 Semesters / 120 Credits
- Program-type: Full-time
- Admission: Aptitude Assessment
- Begin: Winter semester (WiSe) 2004/2005
- Language: English
- Program director: Prof. Dr. Martin Bichler
- Contact person: Johannes Knörr

  Mail: knoerr@in.tum.de

  Phone: 089-289-17508
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1 Degree Program Objectives

1.1 Purpose of the Degree Program

Nowadays, nearly all processes in industry, non-profit organizations and public administration are supported or enabled by information technology (IT). Modern information systems are a prerequisite for the increasing degree of digitization in both business and society and will gain further importance in the future. The resulting social, technological, and economic questions require solutions that equally reflect the requirements of users and suppliers. For understanding, analyzing, and supporting complex processes through IT systems, expertise in computer science as well as management is essential. The Wissenschaftliche Kommission Wirtschaftsinformatik (WKWI) of 2017 emphasizes the substantial relevance of complex information systems in business and administration.

The purpose of the information systems discipline is the development and application of theory, concepts, models, methods, and tools for the analysis and the design of information systems in business and administration. Information systems are constituted by the aggregate of IT-infrastructure, hardware, software, and data developed for a specific task. They are socio-technical systems, i.e., operations are conducted by personnel and mechanical resources. As an interdisciplinary discipline, it addresses the need for integrating computer science and management in order to successfully identify and evaluate technological opportunities. Information system specialists can contribute to the technological and digital transformation and shape the resulting change processes.

The main purpose of the Master's program in Information Systems at the Technical University of Munich (TUM) is to qualify graduates to design, implement, and analyze complex information systems. This includes the design of systems providing management decision support based on the analysis of data available to organizations. For example, various positions in IT departments, business intelligence and data science, or various business functions (e.g., operations management, marketing, controlling) are responsible for designing and implementing respective information systems.

1.2 Strategic Significance of the Program

The study program Information Systems is inherently interdisciplinary and is thus offered in close cooperation with the TUM School of Management, constituting a central link between the School of Management and the Department of Informatics. Due to the number of different specialist departments graduates work in, the study program is of high importance for local business. The interdisciplinary nature of the program is in accordance to the research strategy of the Department of Informatics, which is based on diverse, interdisciplinary research clusters. Students can conduct a research project in the form of "Guided Research" or their Master's thesis, both of which are carried out in close cooperation with a chair at the Department of Informatics. Graduating from the Master's program Information Systems enables graduates to do research in clusters "Algorithmic Economics & Operations Research", "Data Engineering & Analytics" and "Software Engineering & Information Systems" and might, depending on specialization, create opportunities to work in other research areas, too. The strong capabilities of the Department of Informatics in data engineering, software

engineering, algorithmics, and operations research permit a strong focus on informatic methods which gain increasing significance in industry.

The Master's program Information Systems plays an important role in achieving national and international standards regarding quality, diversity, and internationalization in all phases of academic education. Small tutorial groups support the learning process and ensure high quality of teaching in conjunction with lectures. Regular assessments of courses and the study program as a whole serve as basis for continuous improvement of teaching in tutorials and lectures. The window of mobility in the third semester fosters the internationalization of students while conversely the aptitude assessment allows international students to enter the study program. This encourages internationalization and diversity in a meaningful way.

The Technical University of Munich was among the first universities in Germany to offer a study program in Informatics. The Bachelor's and Master's program Informatics initially developed in parallel to the diploma program and replaced it in 2005. By expanding towards Information Systems, the Department of Informatics established another important pillar and introduced respective Bachelor's and Master's programs in 2001. Study programs in Bioinformatics which are offered in cooperation with LMU supplement the portfolio. Since 2011 the Department of Informatics offers the Bachelor's program Informatics: Games Engineering, another fundamental study program which takes job market demands into account and reflects the strengths of the department. A consecutive Master's program Informatics: Games Engineering complements the Bachelor's program.

Specialized Master's programs Computational Science and Engineering (CSE, since 2001), Robotics, Cognition, Intelligence (since 2009), Biomedical Computing (since 2009) und Data Engineering and Analytics (since 2016) allow Bachelor graduates to put emphasis on a particular subject area.

The following figure depicts how the range of studies offered by the Department of Informatics is structured: Study programs are clustered into Bachelor's programs, consecutive Master's programs and Master's programs with specialized topics.
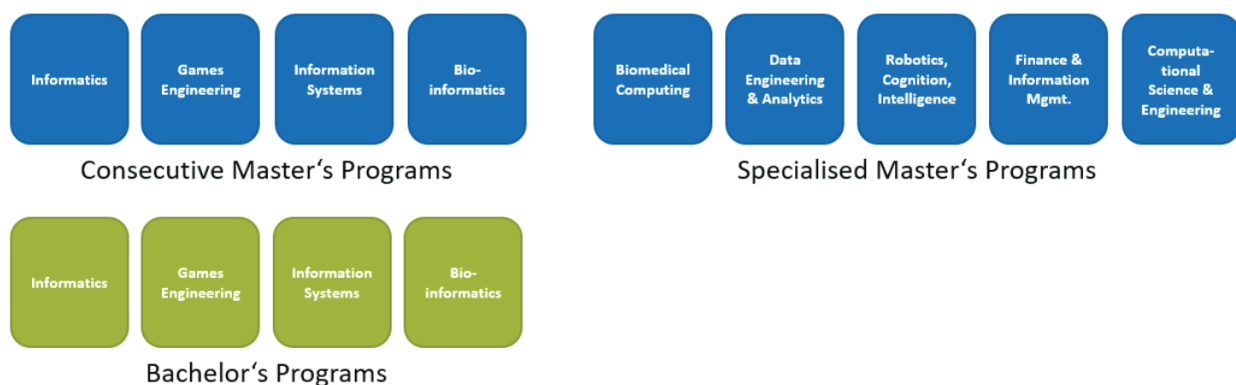

Figure 1: Bachelor's and Master's programs offered by the Department of Informatics

The Master's program Information Systems is rooted in classical education in Information Systems at universities in Germany and is considered as the primary opportunity to complete one's studies in Information Systems by graduates: out of 560 graduates in the Bachelor's program Information

Systems (until including WiSe 2014/15) 394 (70%) subsequently started in the Information Systems Master's program. These 394 graduates make up 65.2% of all 604 new students in the program. 70% of the remaining 210 students are from a national university while 30% are from international universities.

2 Qualification Profile

The following sections are concerned with competencies, skills, and capabilities in the areas of "Knowledge and Understanding", "Use, Application, and Creation of Knowledge", "Communication and Cooperation", and "Scientific Self-Conception / Professionalism" which are conveyed in the Master's program Information Systems. The qualification profile meets the requirements stemming from the Hochschulqualifikationsrahmen (2017).

2.1 Knowledge and Understanding

Graduates can grasp advanced problems in the context of designing and developing information and decision support systems in a holistic way and analyze them in both breadth and depth based on well-founded expert knowledge. The acquired knowledge and skills enable graduates to assess such problems and to develop solution strategies appropriate to the operating context.

Graduates possess a detailed, critical and state-of-the-art understanding of the intersection of computer science, information systems, and management. As emphasized by the WKWI, especially an understanding of the effect mechanisms of software systems as well as development skills are essential.

In the area of software engineering, graduates can develop software in different programming languages and are familiar with software engineering concepts to master large-scale software development projects. Alumni have also in-depth knowledge about data organization and data engineering concepts to design and manage large-scale database and data warehouse infrastructures. Graduates possess advanced skills in data analytics, business process management, algorithms and optimization. These methodological skills are combined with managerial skills. Graduates understand the business context for the design and implementation of information systems and know central problems in the management discipline that require the use of information systems.

2.2 Use, Application, and Creation of Knowledge

Graduates possess competencies from the fields of data and information management, intra- and interorganizational information systems, and models and methods to support decision making. Graduates can integrate and critically reflect on existing and new knowledge from computer science, information systems, and management, enabling them to make scientifically sound decisions and to work autonomously.

Graduates can apply advanced techniques in computer science in the design and the implementation of large-scale, software-intensive systems, and are able to enhance those techniques. For example, they know the operating principles of database systems with regard to query optimization or multi-user systems and are able to analyze and refine such systems. In particular, graduates are able to implement large software systems subject to economic requirements and have gained first experience in the conduct of software projects in a development lab.

Graduates are prepared to take on corporate and management tasks, as well as consulting, or entrepreneurial roles. They know methods and insights from general management relevant to large

companies. Besides, graduates can organize and analyze the data in organizations or optimize processes within or across companies. They possess analytical skills to process large datasets and to facilitate as well as critically reflect on data-driven decision-making.

2.3 Communication and Cooperation

Graduates have proficiency in interdisciplinary communication and are able to work constructively and solution-oriented in a team. They are familiar with specialist vocabulary, working methods and ways of looking at specialist problems at the intersection of computer science and management. In addition, graduates have in-depth English language skills, both written and spoken, as well as international and intercultural competences.

2.4 Scientific Self-Conception / Professionalism

Graduates of the Master's program are qualified for scientific work. Students are able to conduct fundamental or application-oriented research in the field of information systems. They can analyze the current state of research, formulate research hypotheses and draw up a research plan. Furthermore, they can conduct scientific investigations including data collection, data recording and interpretation using adequate methods. Graduates can communicate their research and corresponding results in an appropriate manner, both orally and in writing, both to their own scientific community and to people from outside the discipline. Graduates develop a professional self-conception and can justify and critically reflect on their actions with theoretical and methodological knowledge.

3 Target Groups

3.1 Target Groups

With a Bachelor's degree in Information Systems or a comparable degree, one can enter the Master's program in Information Systems. It is also open to students with a Bachelor of Computer Science, Economics or comparable programs from domestic or foreign colleges and universities with a corresponding focus, whose degree corresponds to a qualified, scientifically oriented Bachelor's degree. If there is a lack of examination results, the commission for the qualification procedure can demand that these examinations must be made up for during the Master's program as additional basic examinations (so-called bridge courses) in order to prove the qualification. For applicants who have not completed their first degree at an institution of higher education in a country of the European Union, proof of specialized knowledge must be provided in the form of a "Graduate Record Examination (GRE) General Test" or in the form of a "Graduate Aptitude Test in Engineering" (GATE) in Computer Science.

With these formal requirements, the Department of Informatics can target the following groups for the Master's degree in Information Systems:

a)   Graduates of the Bachelor's degree programs of the Department of Informatics who would like to complete their education in Information Systems, in particular graduates of the Bachelor's degree program in Information Systems. Students of the other Bachelor's degree programs of the department have the opportunity to specifically acquire any Information Systems competencies that may still be necessary within the scope of their specialization or elective modules. Graduates of the department can already take module examinations from the Master's program in the last phase of the Bachelor's program (e.g. parallel to the Bachelor's thesis), which will be recognized for them later. This enables a smooth transition without loss of time.

b)   Committed graduates of Bachelor's programs of other German-speaking universities and colleges who accept a change of university in order to take advantage of the offer of the Department of Informatics. This includes, in particular, outstanding graduates from the surrounding Bavarian universities of applied sciences (Hochschulen für angewandte Wissenschaft), who acquire the best prerequisites for an academic career with the Master's degree in Information Systems at the Technical University of Munich. Especially for this target group, the bridge courses are a good opportunity to catch up on missing competencies.

c)   Very good graduates from renowned international universities who are interested in studying at the Technical University of Munich.

3.2 Prior Knowledge

The scientific study of Information Systems requires an understanding of abstract, logical and system-oriented issues on the part of the applicants for the course of studies, as well as the necessity of a pronounced ability to express oneself linguistically (also in a foreign language).

In addition, applicants for the Master's program in Information Systems should have proven themselves in a demanding Bachelor's program in which they have acquired the required basic competencies in mathematics, computer science, interdisciplinary fundamentals, and management.

Applicants should possess foundations in linear algebra, calculus, discrete mathematics, operations research, statistics and data analysis, programming, software development, and database systems. They should be acquainted with fundamental concepts in information systems, such as the design of information systems, process modeling, or information management. Basic familiarity with controlling, accounting, and basics of financial mathematics are further prerequisites.

These skills are important prerequisites for success in the course of studies as well as in the professional field and are characteristic and of great importance for the special profile of Information Systems and Informatics at the Technical University of Munich. The curriculum of the Bachelor's program in Information Systems is designed to meet these requirements.

The language of instruction is English; appropriate proof is required. Applicants should be able to adequately demonstrate their motivation and suitability, referring to both the skills acquired during the Bachelor's program and any qualifications beyond that.
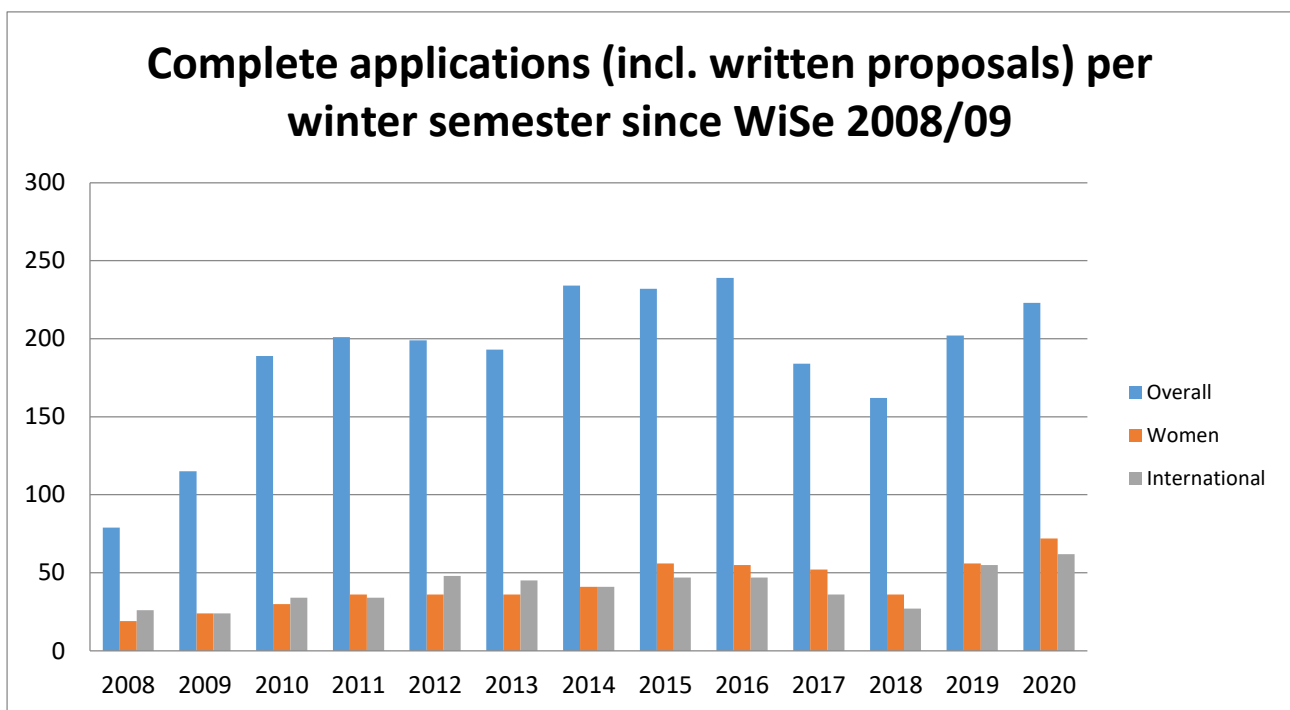
3.3 Target Numbers

Figure 2: Complete applications (incl. written proposals) per winter semester since WS 2008

Overall application numbers rose steadily over many years, with a sharp increase again in 2014 after a random leveling off in 2012 and 2013. The increased number of applicants in 2014 is clearly due to the dual high school graduating class of 2011/12, as these students completed their Bachelor's degrees approximately three years later. The lower application numbers in 2017 and 2018 gave way to a rebound beginning in 2019. The high application numbers of women and internationals also point to a continuing trend.

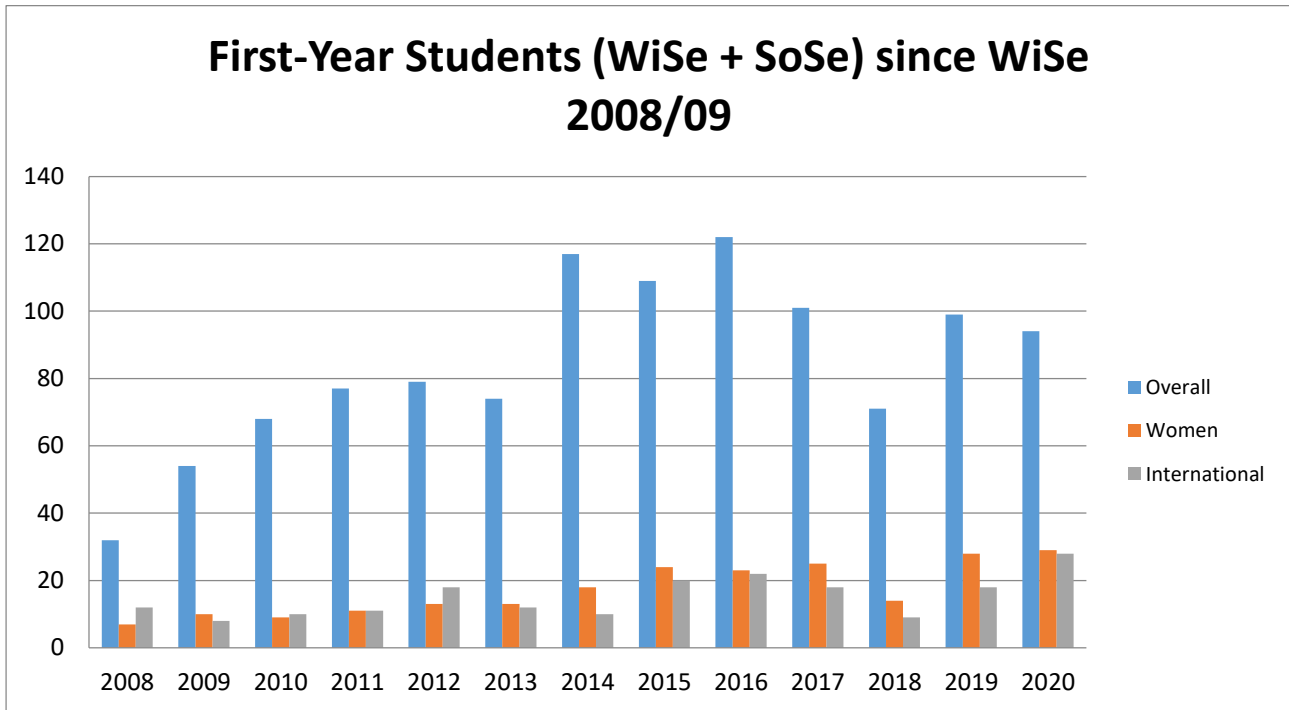**First-Year Students (WiSe + SoSe) since WiSe 2008/09**

Figure 3: First-Year Students (WiSe + SoSe) since WS 2008/09

As can be seen from the graph above, the starting numbers follow the development of the number of applicants. This indicates that the Department of Informatics is able to adjust its capacities according to demand.

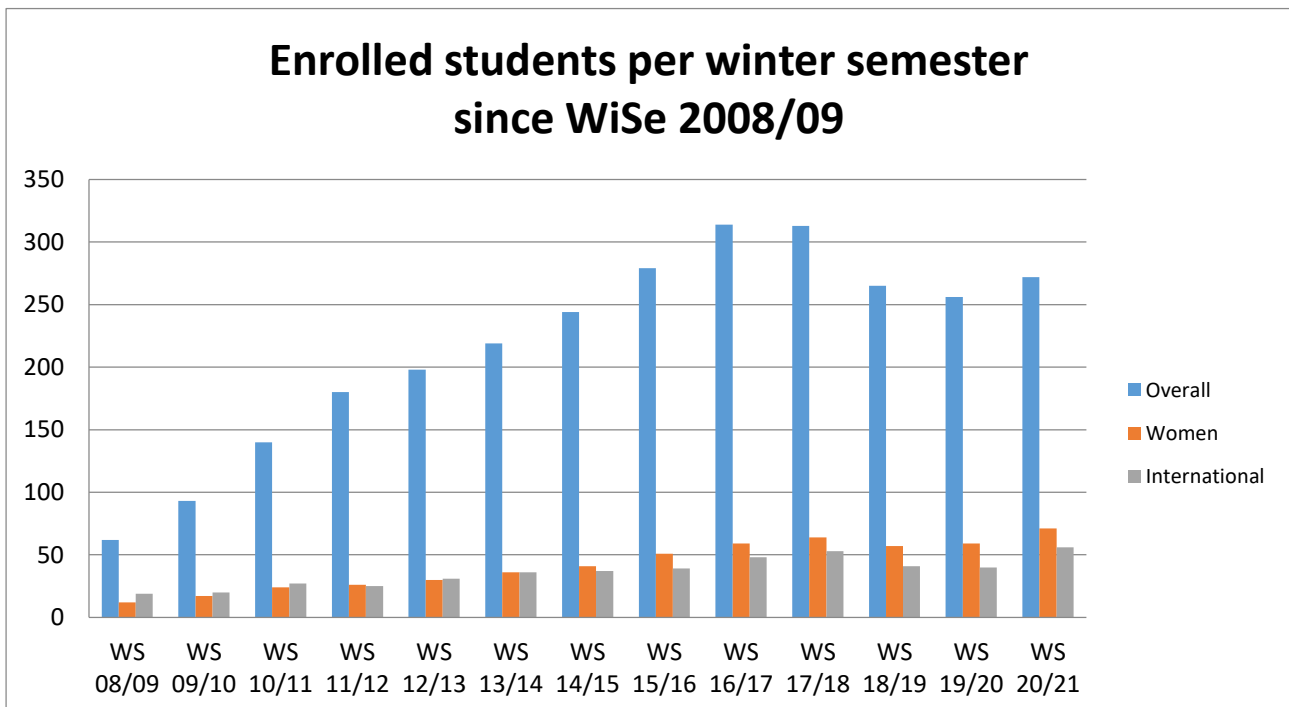**Enrolled students per winter semester since WiSe 2008/09**

Figure 4: Enrolled students per winter semester since WS 2008/09

The same development can be seen with a corresponding time lag in the number of students and graduates: The number of students has been rising sharply since the 2009/10 winter semester. Due to the heterogeneous duration of the Master's program in Information Systems of the students, the

fall in the number of first-year students in 2013 is not reflected in the development of the number of students. Overall, the graph suggests that the Faculty of Computer Science allows all suitable applicants to study for a Master's degree.
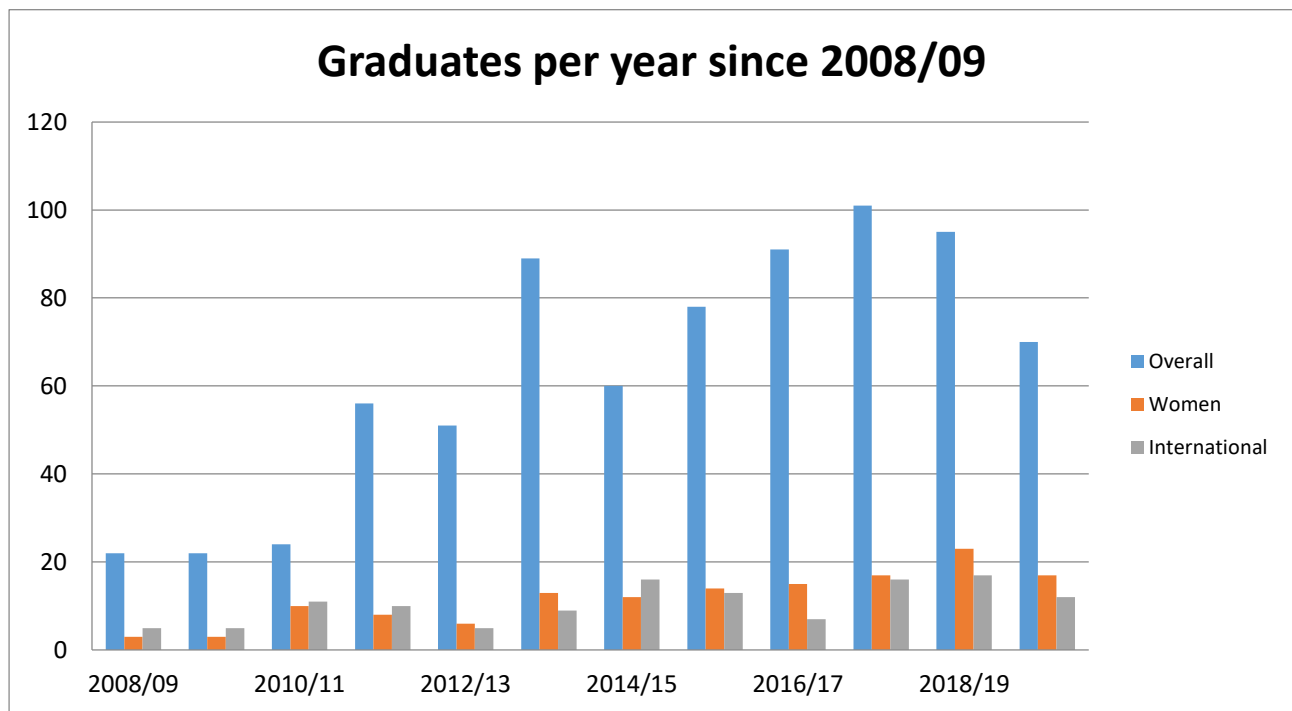

Figure 5: Graduates per year since 2008/09

The number of graduates follows the development of the number of students and has been rising strongly since the 2011/12 academic year. The decline in the 2012/13 academic year is a statistical outlier. This decline can be explained by the fact that the last degree program performance of some graduates has already formally slipped into the 2013/14 academic year. This also explains the very strong increase in the number of graduates in 2013/14.

In the long term, the Department of Informatics aims to strengthen its Master's programs in order to train as many highly qualified specialists as possible for the next generation of scientists and the job market. In the Master's program in Information Systems, a continuous increase in the number of applicants, freshmen, students and graduates has been observed over the past years. In principle, the development follows the structure of the Bachelor's program in Information Systems, taking into account the effects of the double Abitur year. For the next few academic years, an adjustment to a long-term constant level of approximately 200 students per year on average is thus to be expected.

4 Analysis of Need

Bavaria is a high-tech location. In 2015, Bavaria's share of all German patent publications in all fields of technology was around 29% according to the International Patent Classification. Compared to 2012, the share increased by 3 percentage points. Compared to Germany as a whole, Bavaria produces an average factor of 1.7 times more patent publications than would be expected in terms of population, gross domestic product and companies. The Bavarian "Top 20" technologies coincide with 17 of the German and 7 of the European "Top 20" technologies. The technology field "vehicles, vehicle equipment or vehicle parts" with the Bavarian share of 38.2 % is in first place in Germany. The automobile manufacturers in Bavaria dominate this innovation field with their development performance with about two fifths.

In particular, the Munich metropolitan area is an excellent business location: 22.2% of the Bavarian population lives in the Munich region and generates around 31% of Bavaria's gross domestic product.

Munich is Germany's second-largest employment location with around 850,000 employees subject to social insurance in the city area and 1.42 million employees in the region. Employment in Munich has been growing at an above-average rate for seven years - usually well above the 2% mark. With an average share of university graduates of 32.9%, the district of Munich has by far the highest level of qualification (source: Landeshauptstadt München Referat für Arbeit und Wirtschaft, as of February 2018).

Information and communications technology is the mainstay of Munich's industry mix. Nowhere else in Germany are there more companies in the IT, software, communications and media industries than in and around Munich. Thanks to the immediate proximity to IT companies, students can already establish intensive contacts during their studies, for example in the form of a working student job.

In 2017, there were 55,000 vacancies for IT specialists in Germany. This represents an increase of 8% compared to the previous year. More than half of ICT companies (56%) expect the shortage of specialists to worsen in the future (source in each case BITCOM press release of November 07, 2017). The strong IT location of Munich thus brings with it a wide range of jobs, so that TUM students at the Department of Informatics have an excellent starting situation after graduation. The students have very good prerequisites in the IT business with the attainment of the above-mentioned educational specializations.

With its theory-based and practice-oriented education, the Master's program in Information Systems specifically prepares students for careers or bridge functions with an IT focus or for doctoral studies. Graduates are qualified for an employment in IT departments, in software development or with IT service providers. The program provides an excellent basis for software architects, IT project managers, IT consultants and IT service management in general. The role of Chief Information Officer (CIO) is suitable for ambitious students aspiring board-level management positions.

Information System graduates are also suited for central business functions in which informatics and the design, implementation, and analysis of information systems are essential elements:

- For tasks in the area of operations management, procurement, production and supply chain management, both in industry and in large service companies, excellent IT skills and analytical skills are a prerequisite in addition to business management skills.

- Market research and customer relationship management are fields in which skills in organizing and analyzing large amounts of data coupled with marketing know-how are central. The Master's program thus offers very good entry opportunities in business intelligence and marketing departments of banks, insurance companies or telecommunications service providers.

- Controlling is another possible area of employment. The object of controlling is the collection, processing and analysis of data for the preparation of target-oriented management decisions. The program provides students with all the essential business management and IT prerequisites.

- Finally, many companies have established business analytics or data science departments with a focus on data analytics and optimization in a corporate environment. Graduates with a Master in Information Systems have an ideal background with skills in machine learning, optimization, and systems engineering relevant for such departments.

The range of application areas is thus very broad. In these business areas, computer science skills play just as important a role today as optimization skills from mathematics, which are used in supply chain management, for example.

Due to the interdisciplinary training, strategic and operative IT consulting would be other fields of occupation. Graduates can identify complex problems holistically and assess and develop appropriate solutions. Digital transformation projects require a strong technical and analytical capabilities, a reflective and business-driven mindset, as well as a customer orientation and strong communication skills.

The interdisciplinary training with a strong technical and quantitative focus and acquisition of in-depth expert knowledge can also enable graduates for entrepreneurial careers. Graduates are familiar with state-of-the-art technologies and current trends and are furthermore trained to assess business opportunities. They are able to critically reflect on their own professional actions and learn to collaborate constructively in teams.

Overall, specialists in Information Systems possess the mixed qualification from the fields of business administration and computer science that is often sought after on the labor market. They can therefore be employed in various business areas and industries. The coverage of the wide range of specialist tasks and the interdisciplinary orientation ensure that qualified graduates of Information Systems will be able to secure highly remunerated positions on the IT job market in the long term. In the future, regular surveys of students are planned in order to ascertain career opportunities. For this purpose, groups have already been set up in social networks to keep in touch with graduates.

Based on graduate surveys and feedback from the labor market, we continue to examine whether demand is changing or whether the Master's program and its features are optimally suited to the needs of the employment fields in companies.

5 Competition Analysis

5.1 External Competition Analysis

The Bachelor's and Master's degree programs in Information Systems at the Technical University of Munich cover the classical education in the subject of information systems. Internationally, the subject is mainly taught at business schools. In Germany, the majority of information systems courses are offered at business faculties and at some computer science faculties. Throughout Germany, business informatics is taught at the Master's level at more than 100 locations at universities and universities of applied sciences. In Bavaria, a Master's degree in Information Systems is offered by the universities of Bamberg, Erlangen-Nuremberg, Passau, the Bundeswehr University Munich, Regensburg, Augsburg and Würzburg. TUM's content profile is technically oriented and thus differs from the courses offered at other Bavarian universities.

A characteristic feature of the Master's program in Information Systems at TUM is the fact that it was established at one of the largest computer science faculties. The program thus benefits from the broad range of courses offered by the Department of Informatics and achieves an emphasis on core informatics competencies in planning, development and management of complex information systems paired with core business competencies and intensive preparation for management tasks. This information technology orientation can therefore be seen as a special feature in national and international comparison. In the rankings, the study program receives top ratings. For example, in the CHE Ranking (Center for Higher Education Development) 2020, the study program is in the top group for the three indicators "range of courses", "scientific relevance of the study program" and "offers for career orientation". In the Wirtschaftswoche 2020 university ranking, the TUM program is in first place.

5.2 Internal Competition Analysis

The Master's program in Information Systems can be clearly distinguished from the Master's programs in Management and Technology with specialization in Informatics, from the Master's program in Finance & Information Management and from the Master's program in Informatics.

In contrast to the Master's program in Informatics, the Master's program in Information Systems emphasizes the intersection of computer science and management. The design and implementation of information systems in business and administration requires a profound understanding of relevant problems in these domains.

A new Master's program in Information Engineering will be launched at the TUM Heilbronn Campus in the next years. This program puts a greater focus on cyber-physical systems and has a significantly larger share of compulsory modules. It spans topics from computer engineering to computer science in great breadth. In contrast, the Master's program in Information Systems has a clear focus on job profiles at the intersection of IT and business. Hardware-related topics and computer engineering are outside the scope of the Information Systems master. Overall, the Master's program in Information Engineering addresses different target professions and it is offered at the TUM Heilbronn Campus.

The Master's programs Management and Technology with specialization in Informatics prepares students for careers in general management with basic knowledge in information systems and informatics. As the share of modules in the Department of Informatics amounts to 30%, graduates do not possess the same degree of proficiency in computer science subjects. Instead, the main part of the study (70%) contains purely management or economically oriented modules. This composition clearly differs from the interdisciplinary structure of the Master's program in Information Systems, which is made up of equal proportions of coordinated modules from computer science, information systems and management. Similarly, the Master's program in Finance & Information Management, starting in the winter semester 2021/22, combines digital transformation topics with a strong emphasis on finance and risk management. The affiliation with the computer science faculty and its strong technical focus on information systems design and development clearly distinguishes the Master's program in Information Systems. The interdisciplinary structure of the Master's program will be explained in detail in the next chapter 6.

6 Structure of the Study Program

The Master's program Information Systems is designed as a 4-semester and interdisciplinary Master's program. The study can be taken up in the winter as well as in the summer semester.

Based on the "Rahmenempfehlungen für die Universitätsausbildung in Wirtschaftsinformatik der Wissenschaftlichen Kommission Information Systems" (WKWI) of 2017, the content of the focus of the Master's program is divided into the three pillars or areas of computer science, information systems (in the narrow sense), and management, which are summarized in the following illustration and allow for an interdisciplinary education.

Computer Science	Information Systems	Management
Advanced Topics in Software Engineering (Module)	Business Process Technologies and Management (Module)	Management (Area)
Algorithms (Area)	Software Engineering for Business Applications (Module)	
Machine Learning and Data Analysis (Area)	Databases and Information Systems (Area)	
	Information Systems Electives (Area)	
	Development Lab (Area)	
Elective Modules (Area)		
Support Electives (Area)		
Master's Thesis		

Table 1: Content of the Master's program

In order to prepare graduates for information systems design and development, the curriculum includes advanced courses in data and software engineering as well as a development lab. Moreover, the abundance of data in organizations requires strong analytical skills and courses in data analysis, machine learning, optimization and algorithms. Courses in the management discipline allow students to acquire managerial skills and to understand relevant business contexts for the implementation and analysis of information systems.

The Master's program covers the field of Information Systems in a theory-based and practice-oriented manner in the three pillars listed above: In the area of "Computer Science", the program aims to ensure that students understand in-depth principles from the area of software engineering. Students will be familiar with large software systems and be able to develop them further. The curriculum also includes mathematical-statistical modeling, algorithmic methods, and data analytics. Hereby, students acquire strong technical skills to assess the complexity of IT-related challenges and to develop and implement adequate and state-of-the-art solutions.

In the "Information Systems" pillar, students receive in-depth training in process management, software architecture, database systems, and IT management. They learn to integrate complex knowledge from computer science and management studies, enabling them to identify and critically

assess technological challenges and opportunities. In the context of the development lab, students enhance their hands-on programming skills and actively develop digital solutions in small teams, in accordance with the WKWI recommendation. At the same time, this practical training addresses teamwork and students acquire skills in project planning and organization.

The goal of the "Management" education is the treatment and deepening of relevant topics in business administration. Students can specialize in business functions that centrally require the design and implementation of information systems, such as operations management or marketing. Students can further select topics in general management in order to prepare them for future corporate, entrepreneurial, or consulting careers.

Graduates of the Master's program have a clear qualification profile in the business world, which optimizes their competitive chances on the job market. Besides, an individual focus can be set via overarching elective modules and the Master's thesis, allowing to acquire in-depth technical knowledge in one or more specialty areas. Additional support electives foster extracurricular competences and contribute to the students' personal developments.

The following sample curricula provide an overview of the curriculum of the Master's program in Information Systems at TUM.

S	CP	Computer Science	Information Systems	Management
1	30	IN2309 Advanced Topics of Software Engineering Exam 8 CP (Compulsory Module)	IN2396 Advanced Seminar Information Systems Project 5 CP (Information Systems Electives)	WI000836 Advanced Planning in Supply Chains - Illustrating the Concepts and Methodology using SAP IBP Exam 6 CP (Management)
		IN2357 Machine Learning for Computer Vision Exam 5 CP (Machine Learning and Data Analysis)		
		IN2067 Robotics Exam 6 CP (Elective Modules)		
2	30		IN2087 Software Engineering for Business Applications Project 8 CP (Compulsory Module)	WI000234 Value-based Management Exam 6 CP (Management)
			IN2105 Business Process Technologies and Management Exam 5 CP (Compulsory Module)	
			IN2288 Event Processing Exam 5 CP (Databases and Information Systems)	
		IN9048 Innovation Generation in the Healthcare Domain Project 6 CP (Support Electives)		
3	31	IN2211 Auction Theory and Market Design Exam 5 CP (Algorithms)	IN2129 Practical Course Software Engineering for Business Information Systems Project 10 CP (Development Lab)	WI000977 Stochastic Modeling and Optimization Exam 6 CP (Management)
		IN2026 Visual Data Analytics Exam 5 CP (Elective Modules)		
		IN2293 Medical Augmented Reality Exam 5 CP (Elective Modules)		
4	30	IN2109 Master's Thesis Thesis 30 CP		

Figure 6: Exemplary curriculum, begin winter semester

At least 18 CP must be earned from the **Computer Science** module catalog. This includes *"Advanced Topics of Software Engineering"* (8 CP) as a compulsory module as well as modules from the elective areas *Algorithms* (5 CP) and *Machine Learning and Data Analysis* (5 CP), the contents of which are central to most professional fields of Information Systems. This breadth of expertise is essential to guarantee that students master the use algorithms in the development of information systems and to address the growing trend of data-driven decision-making, training students to process and employ large data sets. Accounting for 20% of the required modules (i.e., 18 CP out of 90 CP), it also corresponds to the broad guidelines set by the WKWI, suggesting between 20-25% of computer science modules, excluding the Master's thesis.

In the **Information Systems** pillar with at least 33 CP, 13 CP must be taken through the compulsory modules *"Business Process Technologies and Management"* (5 CP) and *"Software Engineering for Business Applications"* (8 CP). Through these compulsory modules, graduates of the Master's program in Information Systems are specifically prepared for the most fundamental challenges of a career in the information economy: data analysis and process management in business intelligence departments and software development for business information systems. The elective area *Databases and Information Systems* (5 ECTS) is an essential prerequisite to design and analyze information systems. Through an additional elective area *Information Systems Electives* with at least 5 CP, students can deepen their knowledge in relevant areas. Moreover, at least one *Development Lab* with 10 CP must be completed, which covers hands-on development projects w.r.t. enterprise software, software engineering, or process-oriented applications. The Information Systems pillar accounts for 36.67% of the required modules (WKWI recommendation: 25-50%).

S	CP	Computer Science	Information Systems	Management
1	29		IN2087 Software Engineering for Business Applications Project 8 CP (Compulsory Module)	WI000979 Inventory Management Exam 6 CP (Management)
			IN2105 Business Process Technologies and Management Exam 5 CP (Compulsory Module)	
			IN2288 Event Processing Exam 5 CP (Databases and Information Systems)	
			IN2396 Advanced Seminar Information Systems Project 5 CP (Information Systems Electives)	
2	30	IN2309 Advanced Topics of Software Engineering Exam 8 CP (Compulsory Module)	IN2129 Practical Course Software Engineering for Business Information Systems Project 10 CP (Development Lab)	WI000977 Stochastic Modeling and Optimization Exam 6 CP (Management)
		IN2361 Natural Language Processing Exam 6 CP (Machine Learning and Data Analysis)		
3	31	IN2239 Algorithmic Game Theory Exam 5 CP (Algorithms)		WI000234 Value-based Management Exam 6 CP (Management)
		IN2001 Algorithms for Scientific Computing Exam 8 CP (Elective Modules)		
		IN2267 Transaction Systens Exam 6 CP (Elective Modules)		
		IN9048 Innovation Generation in the Healthcare Domain Project 6 CP (Support Electives)		
4	30	IN2109 Master's Thesis Thesis 30 CP		

Figure 7: Exemplary curriculum, begin summer semester

At least 18 CP must be earned in the **Management** pillar. General management topics enhance students' business skills and prepare for the assumption of management tasks. Several offered

modules address the areas of operations management and marketing. Operations management automates and optimizes business processes and nowadays this task is largely facilitated via information systems. Similarly, companies have moved their customer interaction online, often accompanied by the advent of large datasets. Combining these exemplary business functions with expert knowledge in information systems engineering, optimization, and data analytics allows graduates to identify and address central management problems and to contribute to digital transformation processes. The share of the Management pillar is 20% (WKWI recommendation: 20-25%).

The **elective modules** enable an individual profile to be formed according to the students' personal inclinations and career plans. It allows to acquire specialized knowledge and to deepen the interdisciplinary training by the core modules. Elective modules can be chosen from:

- modules from currently 12 subject areas of computer science ("Software Engineering", "Algorithms", "Computer Graphics and Vision", "Databases and Information Systems", "Digital Biology and Digital Medicine", "Formal Methods and their Applications", "Machine Learning and Data Analysis", "Computer Architecture, Computer Networks and Distributed Systems", "Robotics", "Security and Privacy", "Scientific Computing and High Performance Computing", "Human Centered Engineering"),

- modules from the field of management,

- practice-related modules in the field of development labs,

- modules extending the research profile, e.g. guided research.

Further competences, such as linguistic skills or topics overlapping with other disciplines, are acquired as **support electives**, depending on the start of the study in the 1st or 3rd semester. These supplement the subject-specific offering by teaching additional social and personal skills such as interdisciplinary communication and constructive teamwork. At least 6 CP must be earned from this area. The modules form a pool of offerings from the Carl von Linde-Akademie, the Language Center, and the Department of Informatics, from which students can select according to their individual goals. In addition, modules are offered in the area of informatics that aim to impart e.g. legal or PR-related knowledge or knowledge that serves to build up one's own teaching competencies (e.g. as a tutor) or to promote entrepreneurial activities, such as the creation of business plans. The elective modules account for the remaining 23.33% of the required modules (WKWI recommendation: 10-25%).

The **Master's thesis** with a duration of 6 months earns 30 CP and should be written by the students as scheduled in the 4th semester. By answering an independently developed, specific question based on the current scientific discourse with the specialist and methodological knowledge acquired during the course of study, it enables an individual focus to be set and concludes the course of study.

The Master's program Information Systems is characterized by a module concept that includes compulsory and elective modules (see above), which provide module sizes of usually 5-10 CP. Exceptions are modules of the support electives. The faculty points out that especially in the thematic elective areas of IT a choice between modules of larger and smaller size is possible. Further improvements have been made through restructuring within the TUM School of Management, which has been followed in the present study program.

The intended learning outcomes of the elective modules from the support elective catalog belong predominantly to the competence fields of interdisciplinary competences as well as social competences and self-competence. In most cases, the targeted learning outcomes are aligned in such a way that a scope of 3 or 4 CP is sufficient to achieve them.

In order to realize the goal of in-depth education in English, which includes the application of professional knowledge both verbally and in writing, most modules are offered only in English and the final thesis can be written in English. In addition, there is an offer of various language courses in the interdisciplinary basics and the possibility to study abroad. Here, the elective options and the generous recognition regulations for credits earned abroad support a study stay in another country. The third semester is particularly well suited for this (mobility window), because many elective modules are taken in this semester. Thus, a complementary promotion of international and cultural competences of the students is ensured.

For years, there has been close coordination between the Department of Informatics and the TUM School of Management in planning the modules. Attempts are made to bundle the compulsory modules at the respective locations Arcisstraße and Garching to a large extent on specific days. This reduces travel times for students. Exemplary study plans are made available on the Internet before the beginning of each semester. Exemplary schedules are shown in chapter 6 for winter and summer semesters. Non-overlapping schedules are provided in Appendix 9.2 as examples for the start of studies in the winter semester 2021/2022 and for the start of studies in the summer semester 2022.

7 Organization and Coordination

The provider of the program is the Department of Informatics, all professors of the faculty are involved in teaching through the wide range of elective modules. Three chairs of informatics hold the compulsory modules in the Information Systems pillar. The modules from the area "Management" are offered by colleagues from the TUM School of Management.

The subject-specific guidance is carried out by the course guidance of the Department of Informatics, the organization of the aptitude test and the examination administration are carried out by the Office of Academic Affairs (Servicebüro Studium) of the Department of Informatics. The coordination between the Department of Informatics and the TUM School of Management with regard to the modules offered in the study program is carried out by the person responsible for the study program, Prof. Bichler, who is also a second member of the TUM School of Management.
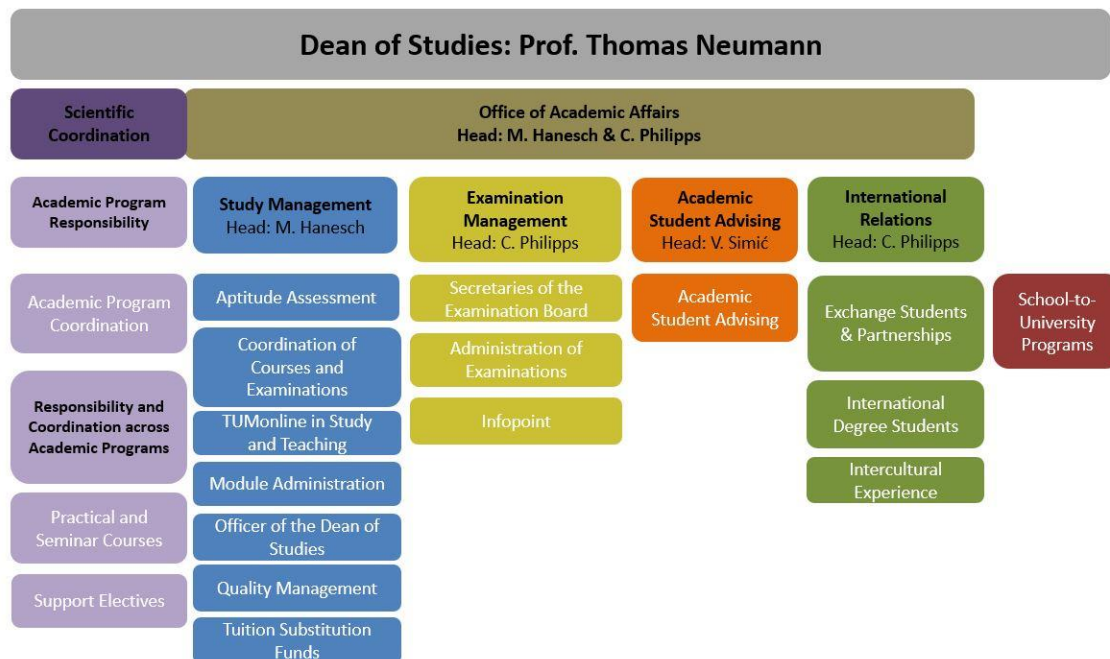

Figure 8: Overview of responsible persons

Dean of Studies: Prof. Dr. Thomas Neumann

Email: thomas.neumann@tum.de

Scientific Coordination

Academic Program Responsibility   Prof. Dr. M. Bichler

Email: bichler@in.tum.de

- Academic Program Coordination

  J. Knörr
  Email: knoerr@in.tum.de

Responsibility and Coordination across Academic Programs

- Practical Courses and Seminar Courses

  Prof. Dr. A. Brüggemann-Klein
  Email: brueggemann-klein@tum.de

- Support Electives

  Prof. Dr.-Ing. D. Burschka
  Email: burschka@tum.de
  P. Gawronski
  Email: peter.gawronski@tum.de

<u>Academic Study Office</u>

Head: M. Hanesch and C. Philipps
Email: monika.hanesch@tum.de,
philipps@tum.de

Academic Study Management

Head: M. Hanesch
Email: monika.hanesch@tum.de

- Aptitude Assessment

  L. Krone
  Email: lena.krone@tum.de
  A. Winkler
  Email: alexandra.winkler@tum.de

- Coordination of Courses

  M. Kozera
  Email: magdalena.kozera@tum.de

- Coordination of Examinations

  E. Brunnbauer
  Email: brunnbauer@mytum.de

- TUMonline in Study and Teaching

  T. Schwanke
  Email: tristan.schwanke@tum.de

- Module Administration

  B. Rosenbaum
  Email: birgit.rosenbaum@tum.de
  T. Schwanke
  Email: tristan.schwanke@tum.de

- Officers of the Dean of Studies

  E. Seedig
  Email: eva.seedig@tum.de
  M. Serbu
  Email: monica.serbu@tum.de

- Quality Management

  B. Rosenbaum
  Email: birgit.rosenbaum@tum.de
  E. Seedig
  Email: eva.seedig@tum.de
  M. Serbu
  Email: monica.serbu@tum.de

- Tuition Substitution Funds

B. Rosenbaum
Email: birgit.rosenbaum@tum.de

Examination Management

Head: C. Philipps
Email: philipps@tum.de

- Secretaries of the Examination Board

A. Fuchs
Email: anna-lisa.fuchs@tum.de
M. Kirchhof
Email: melanie.kirchhof@tum.de

- Administration of Examinations

Z. Millidere
Email: z.millidere@tum.de

- Infopoint

S. Kellerer, S. Kinzel, Z. Millidere, B. Oeckl,
A.Winkler
Phone: 089/289-17593

Academic Study Advising

Head: V. Simić
Email: study-advising@in.tum.de

- Academic Advising

S. Kemler

- Academic Student Advising, Departemental
  contact for chronically ill and disabled students

S. Roden-Kinghorst

Email: study-advising@in.tum.de

International Relations

Head: C. Philipps
Email: philipps@tum.de

- Exchange Students and Partnerships

M. von Imhoff
Email: martina.vonimhoff@mytum.de

- International Degree Students

L. Krone
Email: lena.krone@tum.de

- Intercultural Experience

M. von Imhoff
Email: martina.vonimhoff@mytum.de
L. Krone
Email: lena.krone@tum.de

- https://intranet.in.tum.de/pages/qan6otu81hls/Servicebuero-Studium-SB-S-IN

- https://intranet.in.tum.de/pages/hlqajcu4wyen/Organigramm

8   History of the Study Program

Winter semester 2004/05: The Master's program in Information Systems is offered for the first time as a consecutive Master's degree alongside the Diplom program in Information Systems.

Winter semester 2005/06: The faculty is one of the first informatics departments in Germany to make the complete switch from Diplom to Bachelor and Master programs in accordance with the Bologna Process.

July 31, 2007: The first amendment statute introduces basic tests for better progress monitoring.

July 8, 2008: Revision of the FPSO to align it with the APSO.

December 16, 2009: The first amendment modifies the admission procedure to the extent that aptitude tests already passed can no longer replace the aptitude test.

August 04, 2010: The second amendment specifies deadlines for the subsequent submission of application documents.

August 01, 2012: The third amendment to the statutes updates the mandatory modules by replacing the mandatory module "Software Engineering I: Software Engineering" with "Distributed Systems". In addition, a new elective module area "Software Engineering" is created from which at least 5 CP must be earned.

May 21, 2013: In the fourth amendment, the procedure for awarding basic tests is adjusted and the suitability procedure (Annex 2) is updated.

November 08, 2013: The fifth amendment contains new versions of §36 (qualification requirements) and §41 (study-related examination procedure, forms of examination).

November 06, 2014: The sixth amendment statute adjusts §36.

December 03, 2015: An omnibus amendment revises application and post-submission deadlines faculty-wide.

March 06, 2018: Increase of CP for "Software Engineering for Business Applications - Master Course" from 5 to 8 and adjustment of examination forms in the eighth amendment statute.

September 28, 2018: New FPSO to align the elective module catalog with the new subject areas in the Master of Informatics.

Winter semester 2019/20: Expansion of the elective area and deletion of the module "CIO Business Game".

Winter semester 2021/22: Changed to an English-only study program, restructuring towards more elective subject areas.