3 Degree Plans - Computer Science - Software and Data Engineering

Coordinated by: Department of Software Engineering
Study programme coordinator: Prof. RNDr. Tomáš Skopal, Ph.D.

Specializations:

- Software engineering
- Software development
- Web engineering
- Database systems
- Big data processing

The study program Software and data engineering aims at expertise in analysis, design and development of complex software solutions, and systems focused on big data processing. The portfolio of courses provided in the study covers a number of technological platforms, from classic, web-based, to modern cloud and distributed solutions. A required part of the study is a work on team project where students apply not only the theoretical knowledge and technological skills but also team work abilities.

The graduate gains a deep knowledge of software and data engineering based on her/his specialization. With the specialization Software engineering the graduate is able to analyse requirements for software solutions, to design architectures, and to lead the development process. The specialization Software development prepares the graduate for leading a team of SW developers, including parallel and cloud environments. The development of internet applications is covered by the specialization Web engineering, including web, cloud and other internet technologies with an emphasize on scalability,

robustness and security. The graduate of Database systems is able to design and integrate schemas of various databases and to develop complex database applications. With the Big data processing specialization the graduate is prepared for the role of data scientist with abilities in data mining and related data analytics knowledge.

3.1 Obligatory Courses

Code	Subject	Credits	Winter	Summer
NTIN090	**Introduction to Complexity and Computability**	4	2/1 C+Ex	—
NTIN066	**Data Structures 1**	6	—	2/2 C+Ex
NSZZ023	**Diploma Thesis I**	6	—	0/4 C
NSZZ024	**Diploma Thesis II**	9	0/6 C	—
NSZZ025	**Diploma Thesis III**	15	—	0/10 C

3.2 Elective Courses - Set 1 - Team Project Courses

The student choses one project course from three offered (Software Project, Research Project, Company Project).

Code	Subject	Credits	Winter	Summer
NPRG069	Software Project	12	0/8 C	0/8 C
NPRG070	Research Project	9	0/6 C	0/6 C
NPRG071	Company Project	6	0/4 C	0/4 C
NPRG072	Increased project scope	3	0/2 C	0/2 C

3.3 Elective Courses - Set 2 - Profiling Courses

The student needs to obtain at least 41 credits for the profiling courses from the following set:

Code	Subject	Credits	Winter	Summer
NPRG014	Concepts of Modern Programming Languages	4	0/3 C	—
NPRG043	Recommended Programming Practices	5	—	2/2 MC
NPRG024	Design Patterns	3	—	0/2 MC
NSWI126	Advanced Tools for Software Development and Monitoring	2	—	0/2 C
NPRG059	Advanced Programming Praxis	2	0/1 C	—
NPRG058	Advanced Programming in Parallel Environment	6	2/2 C+Ex	—
NSWI150	Virtualization and Cloud Computing	3	2/0 Ex	—
NSWI153	Advanced Programming of Web Applications	5	—	2/2 C+Ex
NSWI145	Web Services	5	—	2/2 C+Ex
NSWI144	Data on the Web	5	2/1 C+Ex	—
NSWI130	Software System Architectures	5	2/2 C+Ex	—

NSWI026	Advanced aspects of software engineering	5	—	2/2 C+Ex
NTIN043	Formal Foundations of Software Engineering	5	2/2 C+Ex	—
NDBI034	Multimedia Retrieval	4	2/1 C+Ex	—
NDBI040	Modern Database Systems	5	—	2/2 C+Ex
NDBI048	Data Science	5	2/2 C+Ex	—
NDBI042	Data Visualization Techniques	4	—	2/1 C+Ex
NPFL114	Deep Learning	7	—	3/2 C+Ex
NDBI023	Data Mining	5	—	2/2 C+Ex
NDBI016	Transactions	3	—	2/0 Ex
NDBI001	Query Languages 1	5	2/2 C+Ex	—
NDBI006	Query Languages 2	5	—	2/2 C+Ex
NDBI021	User preferences	4	—	2/1 C+Ex
NSWI072	Data Compression Algorithms	3	2/0 Ex	—

3.4 Elective Courses - Set 3

The student needs to obtain at least 15 credits for the courses from the following set:

Code	Subject	Credits	Winter	Summer
NMAI060	Probabilistic Methods	3	2/0 Ex	—
NPRG042	Programming in Parallel Environment	6	—	2/2 C+Ex
NPRG054	High Performance Software Development	6	—	2/2 C+Ex
NSWI035	Principles of Distributed Systems	3	2/0 Ex	—
NSWI080	Middleware	4	—	2/1 MC
NSWI101	System Behaviour Models and Verification	5	2/2 C+Ex	—
NSWI131	Performance Evaluation of Computer Systems	4	—	2/1 C+Ex
NSWI149	Software Engineering in Practice	3	—	2/0 C
NSWI152	Cloud Application Development	3	—	0/2 C
NTIN067	Data Structures 2	3	—	2/0 Ex
NSWI166	Introduction to recommender systems and user preferences	4	2/1 C+Ex	—
NPFL104	Machine Learning Methods	4	—	1/2 C+Ex

3.5 State Final Exam

The student will select three examination areas from the following list. Two of the examination areas are obligatory for the chosen specialization, the last area is chosen voluntarily.

Examination areas

1. Software analysis and architectures (obligatory for the specialization Software engineering)

2. Advanced programming (obligatory for the specializations Software engineering and Software development)
3. Software technologies (obligatory for the specialization Software development)
4. Web technologies (obligatory for the specialization Web engineering)
5. Databases - formal foundations and query languages (obligatory for the specializations Web engineering and Database systems)
6. Databases - implementation and administration (obligatory for the specialization Database systems)
7. Big and unstructured data processing (obligatory for the specialization Big data processing)
8. Data mining (obligatory for the specialization Big data processing)

Knowledge requirements

1. Software analysis and architectures

SW development processes, development phases. Business processes and their modeling using BPMN. UML and its use for analysis and design of structure and behavior of SW. Design patterns. SW testing, impact and change analysis. SW project planning, cost estimation, levels of project management. Legal aspects of SW, principal legal environment for IT projects. Types of SW architecture. Modeling and documentation of SW architecture. Classification of SW architecture quality attributes, their description using scenarios and tactics. Service oriented architectures. Algebraic methods, many sorted algebras, initial models. Temporal logic. Formal principles of the UML language. OCL as a specification language, formal base of specification.

Recommended courses

Code	Subject	Credits	Winter	Summer
NSWI130	Software System Architectures	5	2/2 C+Ex	—
NSWI026	Advanced aspects of software engineering	5	—	2/2 C+Ex
NTIN043	Formal Foundations of Software Engineering	5	2/2 C+Ex	—

2. Advanced programming

Object concepts of modern programming languages. Generic programming and metaprogramming, generics and templates, policies, traits, type inference, reflection. Exceptions, exception-safe programming. Implementation of object properties, runtime support, calling conventions, garbage collection. Modern language constructs and code performance. Parallel programming, Amdahl law, synchronization primitives, task stealing. Design patterns. Scripting languages, prototype-based languages. Domain-specific languages. Functional programming. Principles of code quality, best practices. Refactoring. Testing, debugging, monitoring.

Recommended courses

Code	Subject	Credits	Winter	Summer
NPRG014	Concepts of Modern Programming Languages	4	0/3 C	—
NPRG024	Design Patterns	3	—	0/2 MC

NPRG043	Recommended Programming Practices	5	—	2/2 MC
NPRG042	Programming in Parallel Environment	6	—	2/2 C+Ex
NPRG059	Advanced Programming Praxis	2	0/1 C	—

3. Software technologies

Operating system architectures, process management, memory management, communication and synchronization, parallelism, virtualization, paging. File systems, access rights and security. Portability, multiplatform applications. Testing and monitoring of performance and functionality. Architectures of web applications, server-side and client-side scripting, cooperation with database systems. Architecture of data servers, transactions, performance optimization. Cluster, Grid, and Cloud. IaaS, PaaS, and SaaS. Virtualization, containerization, orchestration, edge computing, IoT. MapReduce. Load balancing, high availability.

Recommended courses

Code	Subject	Credits	Winter	Summer
NSWI126	Advanced Tools for Software Development and Monitoring	2	—	0/2 C
NSWI153	Advanced Programming of Web Applications	5	—	2/2 C+Ex
NSWI150	Virtualization and Cloud Computing	3	2/0 Ex	—

4. Web technologies

Overview of basic web technologies. Network services for web technologies. Web services. Architecture of client-server applications, server-side and client-side scripting, web frameworks. Database systems in web applications, NoSQL databases, multimedia databases. Indexing and document searching, principles of web search engines. Linked Data, integration of semantic data to web pages. Security of information systems in the Internet environment, authentication, authorization, security models, cryptography basics, data security.

Recommended courses

Code	Subject	Credits	Winter	Summer
NSWI130	Software System Architectures	5	2/2 C+Ex	—
NSWI153	Advanced Programming of Web Applications	5	—	2/2 C+Ex
NSWI145	Web Services	5	—	2/2 C+Ex
NDBI034	Multimedia Retrieval	4	2/1 C+Ex	—
NPRG043	Recommended Programming Practices	5	—	2/2 MC

5. Databases - formal foundations and query languages

Relational calculi, relational algebras. Relational completeness. Safe expressions, equivalences of relational query languages. Transitive closure of relation. Semantics of SQL. SQL standards. Object extension of relational data model. Text databases

– Boolean and vector models, searching and indexing, query result ranking, top-k operator. Datalog. Recursion in SQL. XML data model. RDF data model, SPARQL query language. Similarity search in multimedia databases, metric indexes for similarity search. Preference modeling and querying.

Recommended courses

Code	Subject	Credits	Winter	Summer
NDBI040	Modern Database Systems	5	—	2/2 C+Ex
NDBI034	Multimedia Retrieval	4	2/1 C+Ex	—
NDBI001	Query Languages 1	5	2/2 C+Ex	—
NDBI006	Query Languages 2	5	—	2/2 C+Ex
NDBI021	User preferences	4	—	2/1 C+Ex

6. Databases - implementation and administration

Architectures of database systems. Models and properties of transactions: locking protocols, time stamps. Transaction isolation, resource allocation. Distributed transactions. Error/failure recovery, journals. Distribution with horizontal fragmentation, implementation of NoSQL databases, CAP theorem. Indexing relational data. Spatial access methods. Algorithms for implementation of relational operations and aggregation functions. Query evaluation and optimization. Data compression: Huffman coding, arithmetic coding, LZ algorithms, Burrows-Wheeler transformation.

Recommended courses

Code	Subject	Credits	Winter	Summer
NDBI016	Transactions	3	—	2/0 Ex
NSWI072	Data Compression Algorithms	3	2/0 Ex	—
NSWI144	Data on the Web	5	2/1 C+Ex	—
NDBI040	Modern Database Systems	5	—	2/2 C+Ex
NTIN066	**Data Structures 1**	6	—	2/2 C+Ex

7. Big and unstructured data processing

Distribution with horizontal fragmentation, implementation of NoSQL databases, CAP theorem. Big Data management - distribution, scalability, replication, transactions. MapReduce. Key-value storages. Column storages. Document storages. Models for fulltext querying - vector, Boolean, probabilistic models, query result ranking, top-operator. Similarity search in multimedia databases, metric indexes for similarity search. Data visualization techniques. Data science and methodology CRISP-DM - preparation, modeling and evaluation. Basic statistical models for data science.

Recommended coursesy

Code	Subject	Credits	Winter	Summer
NDBI040	Modern Database Systems	5	—	2/2 C+Ex
NDBI034	Multimedia Retrieval	4	2/1 C+Ex	—
NDBI042	Data Visualization Techniques	4	—	2/1 C+Ex
NDBI048	Data Science	5	2/2 C+Ex	—

8. Data mining

Basic principles of database systems, data warehouses and OLAP technology. Data mining – data preprocessing, concept description techniques, methods for mining asso-

ciation rules, methods for data classification and prediction, cluster analysis methods, data mining in database systems. Statistical methods for data mining. Discovery of different types of dependencies. Bayesian analysis, bayesian networks. Probabilistic models of information retrieval. Methods of learning for classification and regression. Support Vector Machines and kernel functions. Experiment evaluation. Data visualization techniques. Data science and methodology CRISP-DM - preparation, modeling and evaluation. Basic statistical models for data science.

Recommended courses

Code	Subject	Credits	Winter	Summer
NDBI023	Data Mining	5	—	2/2 C+Ex
NAIL029	Machine Learning	3	—	2/0 Ex
NDBI042	Data Visualization Techniques	4	—	2/1 C+Ex
NDBI048	Data Science	5	2/2 C+Ex	—