Study plan

Name of study plan: Master specialization Design and Programming of Embedded Systems, in Czech, 2020

Faculty/Institute/Others:

Department:

Branch of study guaranteed by the department: Welcome page

Garantor of the study branch: Program of study: Informatika

Type of study: Follow-up master full-time

Required credits: 98

Elective courses credits: 22 Sum of credits in the plan: 120

Note on the plan: Tato verze studijního plánu je ur ena pro ro níky, které byly p ijaty ke studiu od

akademického roku 2020/2021 do prezen ní formy studia magisterského programu. . Garant: doc. Ing. Hana

Kubátová, CSc., email: Hana.Kubatova@fit.cvut.cz

Name of the block: Compulsory courses in the program

Minimal number of credits of the block: 63

The role of the block: PP

Code of the group: NI-PP.2020

Name of the group: Compulsory Courses of Master Study Program, Version 2020, in Czech

Requirement credits in the group: In this group you have to gain 63 credits

Requirement courses in the group: In this group you have to complete 6 courses

Credits in the group: 63 Note on the group:

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Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-KOP	Combinatorial Optimization Jan Schmidt, Ji í Vysko il, Petr Fišer Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	6	2P+2C	Z	PP
NI-DIP	Diploma Project Zden k Muziká Zden k Muziká (Gar.)	Z	30	270ZP	L,Z	PP
NI-MPR	Master Project Zden k Muziká Zden k Muziká (Gar.)	Z	7		Z,L	PP
NI-MPI	Mathematics for Informatics Št pán Starosta, Jan Sp vák Št pán Starosta Št pán Starosta (Gar.)	Z,ZK	7	3P+2C	Z	PP
NI-PDP	Parallel and Distributed Programming Pavel Tvrdík Pavel Tvrdík (Gar.)	Z,ZK	6	2P+2C	L	PP
NI-VSM	Selected statistical Methods Jitka Hrabáková, Petr Novák, Daniel Vašata, Ivo Petr, Pavel Hrabák, Jana Vacková Pavel Hrabák Pavel Hrabák (Gar.)	Z,ZK	7	4P+2C	L	PP

Characteristics of the courses of this group of Study Plan: Code=NI-PP.2020 Name=Compulsory Courses of Master Study Program, Version 2020, in Czech

NI-KOP	Combinatorial Optimization	Z,ZK	6
The students will gain k	nowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not	only to select and	implement but
also to apply and evalua	ate heuristics for practical problems.		
NI-DIP	Diploma Project	Z	30
NII_MDD	Master Project	7	7

I MI-IVII IX	Master i Toject	_	,	ı
1. At the beginning of the	e semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partia	tasks that should	be carried out	l
during the semester. If the	e requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the e	nd of the semeste	r. 2. The external	l
supervisor enters the inf	ormation on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.	cz/student/studijn	i/formulare). The	l
completed and signed for	orm must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 3. If the FT t	opic that the stude	ent has reserved	l
is rather general, the im	mediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so tha	t the FTT will be o	complete and	l

approvable at the end of the semester.

NI-MPI Mathematics for Informatics Z,ZK 7

The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation.

NI-PDP Parallel and Distributed Programming

ZK

6

21st century in computer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores. Parallel computing systems are becoming a ubiquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platforms. Students get acquainted with architectures of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication operations, and languages and environments for parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and on selected problems, they will learn the techniques of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course includes a semester project of practical programming in OpenMP and MPI for solving a particular nontrivial problem.

NI-VSM Selected statistical Methods

Z,ZK

7

The course leads the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with multivariate normal distribution, application of entropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with random processes with focus on Markov chains. The high point of the course is the Queuing theory and its application in networks.

Name of the block: Compulsory courses in the specialization

Minimal number of credits of the block: 35

The role of the block: PS

Code of the group: NI-PS-NPVS.20

Name of the group: Compulsory Courses of Master Spec. Design and Programming of Embedded Systems,

v. 2020, in Czech

Requirement credits in the group: In this group you have to gain 35 credits

Requirement courses in the group: In this group you have to complete 7 courses

Credits in the group: 35 Note on the group:

Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-BVS	Embedded Security Martin Novotný Martin Novotný (Gar.)	Z,ZK	5	2P+2C	L	PS
NI-BKO	Error Control Codes Pavel Kubalík Pavel Kubalík Pavel Kubalík (Gar.)	Z,ZK	5	2P+1C	L	PS
NI-SIM	Digital Circuit Simulation and Verification Martin Kohlík Martin Kohlík Martin Kohlík (Gar.)	Z,ZK	5	2P+1C	L	PS
NI-TES	Systems Theory Ji í Vysko il, Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-TSP	Testing and Reliability Petr Fišer Martin Da hel Petr Fišer (Gar.)	Z,ZK	5	2P+2C	Z	PS
NI-EHW	Embedded Hardware Jan Schmidt Jan Schmidt Jan Schmidt (Gar.)	Z,ZK	5	2P+1C	Z	PS
NI-ESW	Embedded Software Hana Kubátová, Miroslav Skrbek Hana Kubátová (Gar.)	Z,ZK	5	2P+1C	Z	PS

Characteristics of the courses of this group of Study Plan: Code=NI-PS-NPVS.20 Name=Compulsory Courses of Master Spec. Design and Programming of Embedded Systems, v. 2020, in Czech

NI-BVS	Embedded Security	∠,∠K	5					
Students gain basic knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptographic primitives in hardware								
and software (in embede	and software (in embedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources for securing internal functions							
of computer systems.								
NI-BKO	Error Control Codes	Z,ZK	5					
The goal of the course i	s to present various ways to detect or correct individual errors and burst errors in data stored into memories or transmitted v	ia channels.						
NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	5					
The aim of the course is to acquaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level Modeling) levels and with the								
properties of proper too	ls. The course covers recent verification methods, too.							

NI-TES Systems Theory
Today, humankind has the ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However, the costs of managing this

complexity and of ensuring the correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of models that describe only those aspects of the systems that are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and algorithms that form the basis for the modeling and analysis of complex systems.

NI-TSP Testing and Reliability Z,ZK 5

Students will gain knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prepare a test set with the help of the intuitive path sensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with built-in-self-test equipment. They will be able to compute, analyze, and control the reliability and availability of the designed circuits.

NI-EHW Embedded Hardware Z.ZK 5

The course brings basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the base of advanced embedded systems, that profit from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, including standardized means of internal communication, parallelism extraction and utilization in special structures and system architectures.

NI-ESW Embedded Software Z,ZK 5

Embedded software course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the basic techniques of programming in C language and code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, up to sophisticated techniques combined with artificial intelligence.

Name of the block: Elective courses Minimal number of credits of the block: 0

The role of the block: V

Code of the group: NI-NPVS-VS.20

Name of the group: Elective Vocational Courses for Master Specialization Design and Programming of

Embedded Systems

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0

Note on the group:

All compulsory subjects of specializations with the exception of this specialization.

Note on the group	o: All compulsory subjects of special	izations with	the exc	eption o	f this speci	alizatio
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role
NI-ADM	Data Mining Algorithms Pavel Kordík, Daniel Vašata, Rodrigo Augusto Da Silva Alves Daniel Vašata Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	L	V
NI-AIB	Algorithms of Information Security Martin Jure ek, Róbert Lórencz, Olha Jure ková Martin Jure ek Róbert Lórencz (Gar.)	Z,ZK	5	2P+1C	z	V
NI-ADP	Architecture and Design patterns Filip K ikava, Jan Kurš, Jan Zimolka, Tomáš Chvosta, Ji í Borský Jan Kurš Filip K ikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-AM1	Middleware Architectures 1 Jaroslav Kucha, Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-AM2	Middleware Architectures 2 Jaroslav Kucha, Tomáš Vitvar Jaroslav Kucha Tomáš Vitvar (Gar.)	Z,ZK	5	2P+1C	L	V
NI-BML	Bayesian Methods for Machine Learning Ond ej Tichý, Kamil Dedecius Ond ej Tichý Kamil Dedecius (Gar.)	KZ	5	2P+1C	L	V
NI-DSV	Distributed Systems and Computing Pavel Tvrdík Jan Fesl Pavel Tvrdík (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DDW	Web Data Mining Jaroslav Kucha, Milan Doj inovski Jaroslav Kucha Jaroslav Kucha (Gar.)	Z,ZK	5	2P+1C	L	V
NI-EPC	Effective C++ programming Daniel Langr Daniel Langr (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-EVY	Efficient Text Pattern Matching Jan Holub Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-FME	Formal Methods and Specifications Stefan Ratschan Stefan Ratschan (Gar.)	Z,ZK	5	2P+1C	L	V
NI-GEN	Code Generators Petr Máj, Jan Janoušek Petr Máj Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-GAK	Graph theory and combinatorics Michal Opler Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	5	2P+2C	L	V
NI-HWB	Hardware Security Ji í Bu ek Ji í Bu ek (Gar.)	Z,ZK	5	2P+2C	L	V
NI-KOD	Data Compression Jan Holub Jan Holub (Gar.)	Z,ZK	5	2P+1C	L	V
NI-MKY	Mathematics for Cryptology Martin Jure ek, Róbert Lórencz Róbert Lórencz (Gar.)	Z,ZK	5	3P+1C	L	V
NI-MVI	Computational Intelligence Methods Pavel Kordík Pavel Kordík Pavel Kordík (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MEP	Modelling of Enterprise Processes Robert Pergl, Marek Suchánek Robert Pergl Robert Pergl (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MPJ	Modelling of Programming Languages	Z,ZK	5	2P+1C	Z	V
NI-MTI	Modern Internet Technologies Viktor erný, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	5	2P+1C	z	V
NI-NUR	User Interface Design Josef Pavli ek Josef Pavli ek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-NON	Nonlinear Continuous Optimization and Numerical Methods Jaroslav Kruis Jaroslav Kruis (Gar.)	Z,ZK	5	2P+1C	Z,L	V
NI-NSS	Normalized Software Systems Robert Pergl, Marek Suchánek, Jan Verelst Robert Pergl Robert Pergl (Gar.)	ZK	5	2P	L	V
NI-OSY	Operating Systems and Systems Programming Petr Zemánek, Tomáš Martinec Petr Zemánek Petr Zemánek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-BUI	Business Informatics Petra Pavlí ková Petra Pavlí ková (Gar.)	Z,ZK	5	2P+2C	L	V

NI-PIS	Enterprise Information Systems Vlastimil Jinoch, Martin Závrbský, Martin Mach, Martin Hasaj David Buchtela David Buchtela (Gar.)	Z,ZK	5	2P+1C	L	V
NI-KRY	Advanced Cryptology Ji í Bu ek, Róbert Lórencz Ji í Bu ek Róbert Lórencz (Gar.)	Z,ZK	5	2P+2C	Z	V
NI-PAS	Advanced Aspects of Business David Buchtela, Št pánka Havlíková, Dominik Vítek, Ji í Maršál, Jana Soukupová, Zden k Ku era David Buchtela Zden k Ku era (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-PDB	Advanced Database Systems Yelena Trofimova, Michal Valenta Michal Valenta (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-GPU	GPU Architectures and Programming Ivan Šime ek Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	L	V
NI-PDD	Data Preprocessing Marcel Ji ina Marcel Ji ina (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-REV	Reverse Engineering Josef Kokeš Josef Kokeš (Gar.)	Z,ZK	5	1P+2C	Z	V
NI-RUN	Runtime Systems Filip K ikava Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SWE	Semantic Web and Knowledge Graphs Milan Doj inovski, Jakub Klímek Milan Doj inovski Milan Doj inovski (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SIB	Network Security Ji í Dostál, Simona Forn sek, Martin Šutovský, Martin Holec Simona Forn sek Ji í Dostál (Gar.)	Z,ZK	5	2P+1C	L	V
NI-SCR	Statistical Analysis of Time Series Kamil Dedecius Kamil Dedecius (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SYP	Parsing and Compilers Jan Janoušek Jan Janoušek Jan Janoušek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-SBF	System Security and Forensics Simona Forn sek, Marián Svetlík Simona Forn sek Róbert Lórencz (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-DSS	Decision Support Systems Petra Pavlí ková, Robert Pergl, David Buchtela David Buchtela Robert Pergl (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-TSW	Software Product Development Petra Pavlí ková Ond ej Pluha Petra Pavlí ková (Gar.)	KZ	4	1P+2C	Z	V
NI-UMI	Artificial intelligence Pavel Surynek Pavel Surynek (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-VCC	Virtualization and Cloud Computing Tomáš Vondra, Jan Fesl Tomáš Vondra Tomáš Vondra (Gar.)	Z,ZK	5	2P+1C	L	V
NI-APR	Selected Methods for Program Analysis Filip K ikava Filip K ikava Filip K ikava (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-PON	Selected Topics in Optimization and Numerical mathematics Karel Klouda, Št pán Starosta, Daniel Vašata Daniel Vašata Št pán Starosta (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VMM	Retrieval from Multimedia Ji í Novák, Tomáš Skopal Jaroslav Kucha Tomáš Skopal (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MCC	Multicore CPU Computing Daniel Langr, Ivan Šime ek Ivan Šime ek (Gar.)	Z,ZK	5	2P+1C	Z	V
	the courses of this group of Study Plan: Code=NI-NPVS-VS.20 Natign and Programming of Embedded Systems	me=Elective	Vocatio	nal Cours	es for Ma	ster
-	Data Mining Algorithms			Z		

NI-ADM	Data Mining Algorithms	Z,ZK	5
The course focuses	s on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the stude	nts should know n	nachine learning
basics. The empha	sis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation	systems) and mod	dels (e.g., kernel
methods).			
NI-AIB	Algorithms of Information Security	Z,ZK	5
Students will get ac	equainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, s	tudents will learn t	he mathematical
principles of crypto	graphic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware dete	ection and the use	of machine
learning in detection	n systems. The last topic includes practical steganographic methods and attacks on steganographic systems.		
NI-ADP	Architecture and Design patterns	Z,ZK	5
The objective of thi	s course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysi	s as well as with u	inderstanding of
the challenges, iss	ues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowled	ge of object-orient	ed programming
and get familiar with	n the commonly used object-oriented design patterns that represent the best practices for solving common software design probler	ns. In the second	part the students
will be introduced to	o the principles of software architecture design and analysis. This includes the classical architectural styles, component based syst	ems, and some ad	Ivanced software
architectures used	in large-scale distributed systems.		
NI-AM1	Middleware Architectures 1	Z,ZK	5
Students will study	new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information sys	stem architecture,	web service
architecture and ap	lication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous co	mmunications and	d high availability
of applications.			
NI-AM2	Middleware Architectures 2	Z,ZK	5
Students will learn	new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application archited	tures, concepts a	ind technologies
for microservices.	distrubuted cache and databases, smart contracts, realtime communication and web security.		

NI-BML Bayesian Methods for Machine Learning	KZ	5
The subject is focused on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it stud		
models providing description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidde from noisy observations etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose	•	· ·
and applications will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imagin		
some of them.	3	,
NI-DSV Distributed Systems and Computing	Z,ZK	5
Students are introduced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of compu	• .	
channels. They learn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms the	nat support high av	ailability of both
data and services, and safety in case of failures.	7 71/	
NI-DDW Web Data Mining Students will learn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gair	Z,ZK an overview of W	5 /eh mining
techniques for Web crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an ove		-
in the field of social web and recommendation systems.		
NI-EPC Effective C++ programming	Z,ZK	5
Students learn how to use the modern features of contemporary versions of the C++ programming language for software development. The course f		mming effectivity
and efficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor time requestions. NI-EVY Efficient Text Pattern Matching	Z,ZK	5
NI-EVY Efficient Text Pattern Matching Students get knowledge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both ac		- 1
They will be able to use the knowledge in design of applications that utilize pattern matching.	occo timo ana mor	nory complexity.
NI-FME Formal Methods and Specifications	Z,ZK	5
Students are able to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some		at allow to prove
basic properties of software.		
NI-GEN Code Generators	Z,ZK	5
Advanced techniques of translating programs written in high-level programming languages are essential for understanding the field of systems prog		-
understanding the algorithms and techniques used to translate more complex programming constructs of modern languages employed in systems pi familiar with both the theoretical and practical aspects of implementing the back-end of optimizing compilers for programming languages.	rogramming. Stude	ents will become
NI-GAK Graph theory and combinatorics	Z,ZK	5
The goal of the class is to introduce the most important topics in graph theory, combinatorics, combinatorial structures, discrete models and algorith	1 ' 1	_
on undestanding the basic principles but also on applications in problem solving and algorithm design. The topics include: generating functions, selected	•	
coloring, Ramsey theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theo	ry will be also app	lied in the fields
of combinatorics on words, formal languages and bioinformatics.		
NI-HWB Hardware Security	Z,ZK	5
The course provides the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safegu	-	
using hardware means. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Stu the cryptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions of the c	-	wiedge about
NI-KOD Data Compression	Z.ZK	5
Students are introduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data	, , ,	- 1
used in practice. The overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, s		- 1
lossy data compression methods used in image, audio, and video compression.		
NI-MKY Mathematics for Cryptology	Z,ZK	5
Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers.		
on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discr factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices.	ete logarithm. The	problem of
NI-MVI Computational Intelligence Methods	Z,ZK	5
Students will understand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to		-
how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations, etc.	, ,	,
NI-MEP Modelling of Enterprise Processes	Z,ZK	5
The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approa	ch for (re)engineer	ring and
implementation of processes, organisation structures and information support in big enterprises and institutions.		
NI-MPJ Modelling of Programming Languages	Z,ZK	5
The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preser This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, st		
the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with sema	-	
NI-MTI Modern Internet Technologies	Z,ZK	5
SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration	1 1	-
TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, vio	deo and data to ac	hieve seamless
integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundre		
of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching an technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, dela		
Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of		C.COCI). 4.
NI-NUR User Interface Design	Z,ZK	5
Students will understand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, fo	1 1	-
notions and procesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be able	to design advanc	ed Uls.
NI-NON Nonlinear Continuous Optimization and Numerical Methods	Z,ZK	5
Students will be introduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such me		
will also learn the finite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. T	•	,
linear algebraic equations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to impleme as well as in parallel.	an triese algorithm	is sequerically
·		

NI-NSS Normalized Software Systems Students will learn the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering, such as stability from system theory and entropy from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issues occur in any given software architecture. In the second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. These elements provide the core functionality of information systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability and entropy-related principles. This knowledge allows students to realize new levels of evolvability in software architectures. Operating Systems and Systems Programming The course covers system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel data structures. Key topics are: process management, memory management, file operations and architecture of modern file systems, device drivers and network programming. The course also addresses kernel development process, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability. Specifics of kernel architecture in embedded and real-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs, students will work on projects focused on development of LINUX kernel modules. NI-BUI **Business Informatics** Z.ZK 5 The aim of the course is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of business process management, ICT services and architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT management, and lifecycle management of ICT services and resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governance, the importance of ICT for business and the context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT management, revenue and investment management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO). NI-PIS **Enterprise Information Systems** Z.ZK The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-KRY Advanced Cryptology Students will learn the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the mathematical principles of random number generators. They will have an overview of cryptanalysis methods, elliptic curve cryptography and quantum cryptography, which they can apply to the integration of their own systems or to the creation of their own software solutions. Advanced Aspects of Business 7.7K The aim of the course is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run their own business or business management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related aspects. NI-PDB Advanced Database Systems 5 Students orient themselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of database machines (so called NoSQL databases), with the related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPHER, Gremlin). The last part of the course deals with performance evaluation of database machines. NI-GPU **GPU** Architectures and Programming Z,ZK 5 Students will gain knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUDA programming environment, which is already a widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical computational structures, students will also learn optimization programming techniques and methods of programming multiprocessor GPU systems. **Data Preprocessing** Z,ZK Students learn to prepare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data sources, such as images, texts, time series, etc., and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteristics from images or from web pages NI-REV Reverse Engineering Z.ZK Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. Runtime Systems NI-RUN Z.ZK 5 This course is an introduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience in design and implementation of a compiler and a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compilation Memory management Just-in-time compilation and some optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementations of real-world VMs, including Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs NI-SWE Semantic Web and Knowledge Graphs The students will learn the most recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web technologies, methods and best practices for modelling, integration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge graphs and their systematic quality assurance. NI-SIB **Network Security** Z.ZK 5 NI-SCR Statistical Analysis of Time Series Z,ZK 5 The course deals with the practical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices, employment) and industrial problems (modelling of signals and processes) to computer networks (network components load, attacks detection). The students learn to select a convenient process model, estimate its parameters, analyze its properties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the main principles based on practical real-world examples. Both the lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfer of students' knowledge from NI-SYP Parsing and Compilers Z.ZK 5 The module builds upon the knowledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of various variants and applications of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing. Z,ZK 5 System Security and Forensics Students will get familiar with aspects of system security (principles of end station security, principles of security policies, security models, authentication concepts). Furthermore, students will get familiar with forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensic analysis techniques and the importance of operating system/operating system artifacts or file system for attack analysis and detection).

NI-DSS Decision Support Systems Z,ZK 5
The aim of the course is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of data-oriented, model-oriented and knowledge-oriented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will also learn about the principles of conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods and algorithms.

NI-TSW Software Product Development KZ 4
The course is presented in Czech.

Z.ZK

Z,ZK

5

The main principles and practical applications of discussed techniques will be illustrated.

NI-VCC Virtualization and Cloud Computing Z,ZK 5

The course covers search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programming and automated planning.

Students will gain knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and organizations. They will get acquainted with virtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficiently operate and optimize the performance parameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effective technology today for the management of complex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in the use of modern integration and development tools (Continuous integration and development).

NI-APR Selected Methods for Program Analysis Z,ZK 5

This course introduces you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynamic analysis. In Static Analysis, we will look at the art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimizations, error detection. In Dynamic Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs.

NI-PON | Selected Topics in Optimization and Numerical mathematics | Z,ZK | 5

The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical matematics, mainly numerical linear algebra, are explained too.

NI-VMM Retrieval from Multimedia Z,ZK 5

The student obtains general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feature extraction from multimedia objects, indexing, and structure of distributed search engines.

Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications.

Code of the group: NI-V.2021

Name of the group: Purely Elective Master Courses

Multicore CPU Computing

Artificial intelligence

Requirement credits in the group: Requirement courses in the group:

Credits in the group: 0

Note on the group:

NI-UMI

NI-MCC

In addition to the courses listed here, you can enroll as an elective any course that is offered within your study program and form of study that you did not enroll as a compulsory subject in the program/branch/specialization or a compulsory elective course. Courses of this group that a student has completed in the bachelor study at CTU cannot be re-completed.

has completed in the bachelor study at CTU cannot be re-completed.								
Code	Name of the course / Name of the group of courses (in case of groups of courses the list of codes of their members) Tutors, authors and guarantors (gar.)	Completion	Credits	Scope	Semester	Role		
NI-AOA	Completing a professional event Zden k Muziká	Z	1			V		
NI-ATH	AlgorithmicTheories of Games Dušan Knop, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	4	2P+2C	L	V		
NI-AFP	Applied Functional Programming Robert Pergl, Marek Suchánek, Daniel N mec Robert Pergl Robert Pergl (Gar.)	KZ	5	2P+1C	L	٧		
NI-APH	Architecture of computer games Adam Vesecký Adam Vesecký (Gar.)	Z,ZK	4	2P+1C	Z	V		
NI-VGA	Video Games Architecture Jan Matoušek	Z,ZK	5	2P+1C	Z	V		
NI-BPS	Wireless Computer Networks Ji í Kašpar, Alexandru Moucha Alexandru Moucha (Gar.)	Z,ZK	4	2P+1C	L	V		
NIE-BLO	Blockchain Róbert Lórencz, Jakub R ži ka, Josef Gattermayer, Marek Bielik Josef Gattermayer Róbert Lórencz (Gar.)	Z,ZK	5	1P+2C	Z	V		
NI-CTF	Capture The Flag Ji í Dostál, Martin Šutovský, Ivana Trummová, Ladislav Marko, František Ková Ji í Dostál Ji í Dostál (Gar.)	KZ	4	3C	Z	٧		
NI-DPH	Game Design Adam Vesecký	Z,ZK	5	2P+1C	L	V		
NI-DSW	Design Sprint Ond ej Brém, Michal Manda Michal Manda David Pešek (Gar.)	Z	2	30B	Z	V		
NI-PSD	Public Services Design Ond ej Brém, David Pešek David Pešek Ond ej Brém (Gar.)	KZ	4	1P+2C		V		

NI-DID	Digital drawing Denisa Nová ková, Eliška Novotná Denisa Nová ková Denisa Nová ková	Z	2	4C	Z,L	V
NI-DZO	(Gar.) Digital Image Processing	Z,ZK	4	2P+1C	L	V
NI-DDM	Distributed Data Mining	KZ	4	3C	L	V
NI-PAM	Tomáš Borovi ka Efficient Preprocessing and Parameterized Algorithms Ond ej Suchý Ond ej Suchý Ond ej Suchý (Gar.)	Z,ZK	4	2P+1C	L	V
NI-ESC	Experimental Project Course Jan Matoušek, Ond ej Brém Ond ej Brém (Gar.)	KZ	8	0P+30R+52C	L	V
NI-GLR	Games and reinforcement learning Juan Pablo Maldonado Lopez	Z,ZK	4	2P+2C	L	V
NI-GNN	Graph Neural Networks Miroslav epek Miroslav epek (Gar.)	Z,ZK	4	1P+1C	L	V
NI-GRI	Grid Computing André Sopczak, Petr Fiedler Pavel Tvrdík André Sopczak (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-HCM	Mind Hacking Marcel Ji ina, Josef Holý Marcel Ji ina Marcel Ji ina (Gar.)	ZK	5	2P+1C	Z	V
NI-HSC	Side-Channel Analysis in Hardware Vojt ch Miškovský, Petr Socha Petr Socha Vojt ch Miškovský (Gar.)	Z,ZK	4	2P+2C	Z	V
NI-HMI2	History of Mathematics and Informatics Alena Šolcová Alena Šolcová Alena Šolcová (Gar.)	ZK	3	2P+1C	Z	V
NI-IBE	Information Security Igor ermák	ZK	2	2P	Z	V
NI-IVS	Intelligent embedded systems Miroslav Skrbek Miroslav Skrbek (Gar.)	KZ	4	1P+3C	L	V
NI-IKM	Internet and Classification Methods Martin Hole a Martin Hole a (Gar.)	Z,ZK	4	1P+1C	L	V
NI-IAM	Internet and Multimedia	Z,ZK	4	2P+1C	L	V
NI-IOT	Internet of Things Jan Jane ek	Z,ZK	4	2P+1C	L	V
FITE-EHD	Introduction to European Economic History Tomáš Evan	Z,ZK	3	2P+1C	L	V
NI-KTH	Combinatorial Theories of Games Tomáš Valla Tomáš Valla (Gar.)	Z,ZK	4	2P+1C	L	V
NI-FMT	Finite model theory Tomáš Jakl Tomáš Jakl (Gar.)	Z,ZK	4	2P+1C	L	V
NI-CCC	Creative Coding and Computational Art Radek Richtr, Josef Kortán Radek Richtr Radek Richtr (Gar.)	KZ	4	1P+2C	Z,L	V
NI-KYB	Cybernality	ZK	5	2P	Z	V
NI-LSM2	Statistical Modelling Lab Kamil Dedecius Kamil Dedecius (Gar.)	KZ	5	3C	Z,L	V
NI-LOM	Linear Optimization and Methods Dušan Knop Dušan Knop Dušan Knop (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-MPL	Managerial Psychology Jan Fiala Jan Fiala (Gar.)	ZK	2	2P	Z,L	V
NI-MSI	Mathematical Structures in Computer Science Jan Starý	Z,ZK	4	2P+1C	L	V
NI-MZI	Mathematics for data science Št pán Starosta	Z,ZK	4	2P+1C	L	V
FIT-ITI	Modern IT infrastructure Ivan Šime ek	Z,ZK	5	2P+1C	Z,L	V
NI-MOP	Modern Object-Oriented Programming in Pharo Jan Blizni enko Robert Pergl Robert Pergl (Gar.)	KZ	4	3C	Z	V
NI-NLM	Neural Language Models	Z	5	2P+1C	L	V
NI-NMS	Neural Networks, Machine Learning and Randomness Martin Hole a	Z,ZK	4	1P+1C	Z	V
NI-NMU	New media in art and design Zden k Svejkovský Zden k Svejkovský (Gar.)	ZK	3	2P+0C	Z	V
NI-OLI	Linux Drivers Jaroslav Borecký, Miroslav Skrbek Jaroslav Borecký Miroslav Skrbek (Gar.)	Z,ZK	4	2P+2C	L	V
NIE-PML	Personalized Machine Learning Rodrigo Augusto Da Silva Alves Karel Klouda Rodrigo Augusto Da Silva Alves (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-ARI	Computer arithmetic Pavel Kubalík Pavel Kubalík Alois Pluhá ek (Gar.)	Z,ZK	4	2P+1C	Z,L	V
NI-PG1	Computer Grafics 1 Radek Richtr Radek Richtr (Gar.)	ZK	4	2P+1C	L	V
NI-PIV	Computer Vision Radek Richtr	Z,ZK	5	2P+2C	Z	V
NI-EDW	Enterprise Data Warehouse Systems Jakub Krej í, Robert Kotlá Jakub Krej í Magda Friedjungová (Gar.)	Z,ZK	5	1P+1C	L	V
NI-PVR	Advanced Virtual Reality Petr Pauš Petr Pauš (Gar.)	KZ	4	2P+1C	Z	V

NI-AML	Advanced machine learning Zden k Buk, Miroslav epek, Rodrigo Augusto Da Silva Alves, Petr Šimánek, Vojt ch Rybá Miroslav epek Miroslav epek (Gar.)	Z,ZK	5	2P + 1C	L	V
NI-IOS	Advanced techniques in iOS applications Rostislav Babá ek, Jakub Olejník, Igor Rosocha Martin P Ipitel Martin P Ipitel (Gar.)	KZ	4	2P+2C	L	V
NI-APT	Advanced Program Testing Pierre Donat-Bouillud Pierre Donat-Bouillud (Gar.)	Z,ZK	5	2P+1C	Z	V
NI-PVS	Advanced embedded systems Miroslav Skrbek	Z,ZK	4	2P+2C	Z	V
NI-DNP	Advanced .NET David Šenký , Nikolas Jíša David Šenký Nikolas Jíša (Gar.)	Z,ZK	4	2P+1C	Z	V
NI-PYT	Advanced Python Miroslav Hron ok	KZ	4	3C	Z	V
NIE-PDL	Practical Deep Learning Martin Barus, Yauhen Babakhin Karel Klouda Karel Klouda (Gar.)	KZ	5	2P+1C	Z	V
NI-GOL	Programming of distributed systems in GO	KZ	5	0P+3C	Z	V
NI-PSL	Programming in Scala	Z,ZK	4	2P+1C	Z	V
NI-RUB	Ji í Dan ek Ji í Dan ek Ji í Dan ek (Gar.) Programming in Ruby	KZ	4	3C	Z	V
NI-ROZ	Cyril erný Cyril erný Cyril erný (Gar.) Pattern Recognition	Z,ZK	5	2P+1C	Z	V
NI-PLS1	Radek Richtr, Michal Haindl Michal Haindl Michal Haindl (Gar.) Programming Language Seminar	Z	2	0P+1C	Z	V
NI-PLS3	Pierre Donat-Bouillud Programming Language Seminar	Z	2	0P+1C	Z	V
NI-PLS2	Pierre Donat-Bouillud Programming Language Seminar	Z	2	0P+1C	L	V
NI-PLS4	Pierre Donat-Bouillud Programming Language Seminar Pierre Donat-Bouillud, Filip K ikava Pierre Donat-Bouillud, Pierre	Z	2	0P+1C	L	V
NI-SCE1	Donat-Bouillud (Gar.) Computer Engineering Seminar Master I	Z	4	2C	L,Z	V
NI-SCE2	Hana Kubátová Miroslav Skrbek Hana Kubátová (Gar.) Computer Engineering Seminar Master II Hana Kubátová Hana Kubátová Hana Kubátová (Gar.)	Z	4	2C	L,Z	V
NI-SZ1	Knowledge Engineering Seminar Master I	Z	4	2C	L,Z	V
NI-SZ2	Pavel Kordík Magda Friedjungová (Gar.) Knowledge Engineering Seminar Master II	Z	4	2C	L,Z	V
PI-SCN	Pavel Kordík Magda Friedjungová (Gar.) Seminars on Digital Design Petr Fišer Petr Fišer (Gar.)	ZK	4	2P+1C	Z,L	V
NI-MLP	Machine Learning in Practice	Z,ZK	5	2P+1C	Z	V
FIT-SEP	Jan Hu in Daniel Vašata Daniel Vašata (Gar.) World Economy and Business	Z,ZK	4	2P+2C	L	V
NI-SEP	World Economy and Business	Z,ZK	4	2P+1C	Z,L	V
NI-TVR	Tomáš Evan Tomáš Evan Tomáš Evan (Gar.) Virtual Reality Technology	Z,ZK	3	1P+1C	L,Z	V
NI-TS1	Tomáš Nová ek Tomáš Nová ek Tomáš Nová ek (Gar.) Theoretical Seminar Master I	Z	4	2C	Z	V
NI-TS2	Dušan Knop, Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) Theoretical Seminar Master II	Z	4	2C	L	V
NI-TS3	Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) Theoretical Seminar Master III	Z	4	2C	Z	V
NI-TS4	Ond ej Suchý, Tomáš Valla Tomáš Valla Tomáš Valla (Gar.) Theoretical Seminar Master IV	Z	4	2C	L	V
NI-TKA	Ond ej Suchý, Tomáš Valla Tomáš Valla Ond ej Suchý (Gar.) Category Theory	Z,ZK	4	2P+1C	L	V
NI-TNN	Jan Starý Jan Starý Jan Starý (Gar.) Theory of Neural Networks	Z,ZK	5	2P+1C	L	V
NI-CPX	Martin Hole a Martin Hole a Martin Hole a (Gar.) Complexity Theory Differ Many Cond of Suphic Ond of Suphic Cond	Z,ZK	5	3P+1C	Z	V
FI-TOP	Dušan Knop, Ond ej Suchý Ond ej Suchý Ond ej Suchý (Gar.) Academic writing	Z	2	10B	Z	V
NI-DVG	Introduction to Discrete and Computational Geometry Maria Saumell Mendiola Maria Saumell Mendiola (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VOL	Elections Dušan Knop Dušan Knop (Gar.)	Z,ZK	5	2P+1C	L	V
NI-VYC	Computability Jan Starý Jan Starý Jan Starý (Gar.)	Z,ZK	4	2P+2C	L	V
NI-VPR	Research Project Št pán Starosta Št pán Starosta Št pán Starosta (Gar.)	Z	5		Z,L	V

NI-ZS10	Master internship abroad for 10 credits Zden k Muziká Zden k Muziká (Gar.)	Z	10		Z,L	V
NI-ZS20	Master internship abroad for 20 credits Zden k Muziká Zden k Muziká (Gar.)	Z	20		Z,L	V
NI-ZS30	Master internship abroad for 30 credits Zden k Muziká Zden k Muziká (Gar.)	Z	30		Z,L	V
haracteristics of th	e courses of this group of Study Plan: Code=NI-V.2021 Name=P	urely Electiv	e Master	Courses		
l l	ompleting a professional event				Z	1
nust be approved in advar	in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, con ce by the vice-dean for pedagogical activities or the vice-dean for science and research		-	IT through	a website, in	
	IgorithmicTheories of Games				.,ZK	4
	a branch of mathematics, which has broad applications in economy, biology, politics and			•		•
	etitive process by designinng a mathematical model and investigating the strategies. The		-			-
	game where no player wants to deviate from his strategy. Due to the recent development ner concepts the algorithmic point of view is gaining attention. In addition to existential q	•				
	purse we introduce the basics of game theory of many players, solution concept (usually	-	-		-	on or variou
		equilibria) and n	ietilous oi ti			
1	pplied Functional Programming			1	KZ	5
	Czech. Functional programming represents one of the traditional programming paradig					
	functional paradigm becomes an important construct of traditionally imperative language	es (C++, C#, Java	a). As such,	mastering th	nis paradigm	becomes a
	a software engineer: the theory and especially the practice.					
	rchitecture of computer games			1	,ZK	4
tudents will gain a basic u	nderstanding of the various issues in the field of computer games development, especially	from a technical p	point of view,	but also fro	m design and	d philosophi
erspective. They will get a	grasp of component-oriented and functional-oriented architecture, game mechanics, dec	cision-making pro	cesses and	base compo	nents that fo	orm an integ
art of most games. They v	vill also understand the basics of pathfinding, networking and scripting and apply them in	n practical exercis	ses (labs). A	n important	part of the c	ourse is an
nplementation of a simple	game, with a strong focus on nontrivial game mechanics.					
II-VGA V	ideo Games Architecture			Z	,ZK	5
he course covers a wide	ange of topics, procedures and methodologies related to the development of computer	games - from a te	chnical poir	nt of view, bu	it also from a	a design an
hilosophical point of view.	In the lectures, students will be guided through the history of development, the structure	e of game engines	s, componer	nt and functi	onal archited	cture typica
ame development, physic	s, graphics, artificial intelligence and multiplayer. The exercises will then cover selected to	echnological topic	s in greater	detail, inclu	ding ways of	implement
ome game mechanics, in	the form of practical demonstrations.					
II-BPS W	/ireless Computer Networks			Z	.ZK	4
	e modern technologies, protocols, and standards for wireless networks. They will under	atand tha rauting		. '	, 1	
dadina wiii idaini abdat ti		stand the routing	mechanism	s in ad-hoc	networks, mı	ulticast and
	d data flow control mechanisms. They will also learn about principles of communication	_				
proadcast mechanisms, ar	- · · · · · · · · · · · · · · · · · · ·	in sensor networl	ks. They get			
oroadcast mechanisms, and cor wireless networks and c	d data flow control mechanisms. They will also learn about principles of communication get skills of configuration of wireless network elements and simulation of wireless network	in sensor networl	ks. They get	knowledge	of security m	nechanisms
oroadcast mechanisms, and or wireless networks and only B	d data flow control mechanisms. They will also learn about principles of communication get skills of configuration of wireless network elements and simulation of wireless netwood lockchain	in sensor networl	ks. They get tools.	knowledge	of security m	nechanisms 5
roadcast mechanisms, and governments and governments and governments will understand the	d data flow control mechanisms. They will also learn about principles of communication get skills of configuration of wireless network elements and simulation of wireless netwood lockchain e foundations of blockchain technology, smart contract programming, and gain an overvi-	in sensor networl	ks. They get tools.	knowledge	of security m	nechanisms 5 able to desi
roadcast mechanisms, and gradients networks and gradients. BLO Butudents will understand the ode and deploy a secure	d data flow control mechanisms. They will also learn about principles of communication get skills of configuration of wireless network elements and simulation of wireless network lockchain e foundations of blockchain technology, smart contract programming, and gain an overvidecentralized application, and assess whether integration of a blockchain is suitable for	in sensor network rks using suitable ew of most notabl a given problem.	ks. They get tools. e blockchair The course	knowledge Z n platforms.	C,ZK They will be a creased emp	5 able to design
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NI-PAM Efficient Preprocessing and Parameterized Algorithms There are many optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often necessary to solve these problems exactly in practice. We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one can find a common property (parameter) of the inputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity exponentially in this (small) parameter and polynomially in the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial time preprocessing of the input, which is not possible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solution method. We will present a plethora of parameterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (presumably) does not exist. We will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximation schemes. **Experimental Project Course** NI-ESC 8 K7 The Design Project course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, methodologies, and tools used in designing technology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design projects, collaborate with industry experts, and learn to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills in user-centered design and user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution." Games and reinforcement learning NI-GLR Z,ZK The field of reinforcement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligence. This course is intended to give you both theoretical and practical background so you can participate in related research activities. Presented in English. NI-GNN **Graph Neural Networks** Z.ZK 4 The course introduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural networks for creating vector representations of nodes, edges and entire graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last part of the course also covers graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and problems. Z,ZK NI-GRI **Grid Computing** 5 Grid computing and gain knowledge about the world-wide network and computing infrastructure. NI-HCM ZK 5 Mind Hacking Cognitive security is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, information systems and assets, the domain of cognitive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security is growing in importance in the context of information warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet environment have real societal impacts such as disruption of social cohesion, threats to democracy or war. NI-HSC Side-Channel Analysis in Hardware 7.7K This course is dedicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attacks. Students get familiar with various kinds of side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and get familiar with higher-order attacks. They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel information leakage. NI-HMI2 History of Mathematics and Informatics 3 ZK. This course is presented in Czech. Selected topics {Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms, transformations, recursive functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its development. NI-IBE Information Security 2 Students learn information and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and international standards in this area. They understand methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g., penetration testing) NI-IVS Intelligent embedded systems 4 Intelligent embedded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The course is an advance version of the Intelligent embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programming and advance application development. Lectures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students develop advanced applications combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technologies NI-IKM Internet and Classification Methods 4 Z,ZK In this course, the students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering, in recommendation systems, in malware detection systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving these four kinds of problems. On the background of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle with 2-hour lectures and 2-hour exercises. During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consult their semester tasks. Internet and Multimedia The NI-IAM course is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acquisition of AV signals (input), presentation of AV signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical use case scenarios of real-time audiovisual transmissions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effect of various components on the quality and latency of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the scene up to the presentation for audience. NI-IOT Internet of Things Z.ZK The subject is focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is familiarization with available development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (GNU Forth). FITF-FHD Introduction to European Economic History 7 7K The course introduces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global economy through the description of the key periods in history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic history. From large economic area of Roman Empire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutions is deciphered. The course does not cover detailed economic history of particular European countries but rather the impact of trade and role of particular events, institutions and organizations in history. Class meetings will consist of a mixture of lecture and discussion. NI-KTH Combinatorial Theories of Games Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics

NI-FMT	Finite model theory	Z,ZK	4
	to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability		
•	stion in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as	descriptive comp	lexity theory, the
	Problem (CSP), the theory of algorithmic meta-theorems and combinatorics.	1/7	
NI-CCC	Creative Coding and Computational Art	KZ	4
•	cal tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows t		
•	udents to suitable visualization methods for traditional as well as for open data. It combines well-known visualization techniques as in the contract of the suitable of the s		_
(Institute of Intermedia	he aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture an ==। \	d Metropolitari Fi	aririirig) ariu ilivi
NI-KYB	Cybernality	ZK	
	Cybernamy d with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand th	ı	of attacks and
	tems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker a		
•	operation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams).	ouvillos ana bone	Wich The course
NI-LSM2	Statistical Modelling Lab	KZ	5
_	vanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the pre	l l	_
	he-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters.		vidoo ii.doiigi
NI-LOM	Linear Optimization and Methods	Z,ZK	5
	cations of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear		_
	timization software and are familiar with languages used in programming of that software. They get skills in formalization of o		
science (such as sched	uling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, trave	elling salesman p	roblems, etc.),
issues from economics	and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. T	hey get orientation	on in algorithms
in linear programming.			
NI-MPL	Managerial Psychology	ZK	2
NI-MSI	Mathematical Structures in Computer Science	Z,ZK	4
Mathematical semantic	s of programming languages. Data types as continous lattices, Scott topology. Procedures as continuous mappings. The Scott	' '	a calculus.
Introduction to category			
NI-MZI	Mathematics for data science	Z,ZK	4
	are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in		ne studied topics
include mainly: linear al	gebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality princ	ciple, gradient me	ethods) and
selected notions from p	robability theory and statistics.		
FIT-ITI	Modern IT infrastructure	Z,ZK	5
NI-MOP	Modern Object-Oriented Programming in Pharo	KZ	4
Object-oriented program	nming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, whe	ere its ability to na	tural abstraction
	modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the sl	-	
of object systems in mo	dern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development	needs and areas	of interest In
- 4-144 4- 4			or interest. In
addition to deepening of	bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to wor		
	bject programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work f semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involved.	rk on interesting p	orojects and OO
		rk on interesting p	orojects and OO
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technologies in terms o NI-NLM In this course, students	semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involve Neural Language Models	rk on interesting perment in the Pha	orojects and OO ro Consortium.
technologies in terms o NI-NLM In this course, students	Semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involve Neural Language Models will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models.	rk on interesting perment in the Pha	orojects and OO ro Consortium.
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NI-EDW	Enterprise Data Warehouse Systems	Z,ZK	5
· ·	arehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods arehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to		_
visualization.	and house and various distinctions, but also their deployment and maintenance. This source also molecus an infradeduction to	o and and on ropor	and data
NI-PVR	Advanced Virtual Reality	KZ	4
	advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D moderns to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will a		-
-	(mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the		
-	tly create a complex game for VR.		•
NI-AML	Advanced machine learning	Z,ZK	5
	tudents to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with the		
NI-IOS	Advanced techniques in iOS applications	KZ	4
	atest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all th		beginners class
BI-IOS.			
NI-APT	Advanced Program Testing sential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The	Z,ZK	5 is to present
	ng techniques, beyond writing unit tests, especially fuzzing and symbolic execution.	goal of the course	is to present
NI-PVS	Advanced embedded systems	Z,ZK	4
	on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advar		
working with mass stora systems.	age devices, motor control, system control and industrial communication. The students obtain both theoretical and also practi	cal experiences w	ith embedded
NI-DNP	Advanced .NET	Z,ZK	4
Students will acquire ar	n overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI	(WPF, UWP), Blaz	
	evOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilized (Olsean Mark Mark) and class Arms Day Operand CIT.	ing technologies A	ASP.NET Core,
NI-PYT	and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT. Advanced Python	KZ	4
	ا is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Pyth	I I	=
very hands-on and it ha	s only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursew	ork. The course is	lead by external
teachers from Red Hat.			
NIE-PDL	Practical Deep Learning I to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine	KZ	5 •k Throughout
	I develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields su	_	_
language processing.		•	
NI-GOL	Programming of distributed systems in GO	KZ	5
NI-PSL	Programming in Scala	Z,ZK	4
	the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language feat y. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks	٠.	•
Scalaz, etc.	y. Odala eriables to use of applications functional patterns e.g. Fredst, worlday, etc. Odala is used by maily powerful frameworks	and libraries e.g. i	iay, Cassariura,
NI-RUB	Programming in Ruby	KZ	4
This course is presente			
	Pattern Recognition	Z,ZK	
	is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the s ill learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, ar		•
NI-PLS1	Programming Language Seminar	Z	2
The Programming Lang	juage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which	ch we discuss scie	entific papers
	guages and related fields. Participating students are expected to present a paper of their interest and actively participate in the	ne discussions. Th	e reading group
NI-PLS3	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. Programming Language Sominar	Z	2
	Programming Language Seminar Juage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in whic		
	guages and related fields. Participating students are expected to present a paper of their interest and actively participate in the		
	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
NI-PLS2	Programming Language Seminar puage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in whic	Z	2
	guages and related fields. Participating students are expected to present a paper of their interest and actively participate in the		
	n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.		
NI-PLS4	Programming Language Seminar	Z	2
	juage Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which		
	guages and related fields. Participating students are expected to present a paper of their interest and actively participate in th n FIT and MFF CUNI. It is open to all students and researchers interested in programming languages.	ie discussions. Th	e reading group
NI-SCE1	Computer Engineering Seminar Master I	Z	4
•	ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance		
	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of t	=	
semester.	ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teach	onera. The topics a	are riew ioi each
NI-SCE2	Computer Engineering Seminar Master II	Z	4
· · · · · · · · · · · · · · · · · · ·	ter Engineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance		
• •	ually within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of t ssional literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teac	-	
semester.	solonal incratare and/or work in the relaconatories. The capacity of the subject is illilled by the possibilities of the semilial teat	onera. The topics a	are new ioi each
JUITOJUI.			

NI-S71 Knowledge Engineering Seminar Master I On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and Al conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). Knowledge Engineering Seminar Master II On this seminar you will present a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research labs around the world. Additionally, you will learn how to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machine learning and Al conferences and summer schools, as well as FIT's own Summer Research Program (VyLet). PI-SCN Seminars on Digital Design ZK This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic synthesis and optimization algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial problems emerging in EDA. NI-MLP Machine Learning in Practice 7.7K Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, technical implementation. The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The aim is to experience real data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and understandable report. World Economy and Business This course is presented in Czech. The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom. corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite. NI-SEP World Economy and Business Z,ZK 4 This course is presented in Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite. NI-TVR Virtual Reality Technology Z.ZK Students will be introduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD, ...) and the possibilities of controlling virtual avatars (position tracking, hand tracking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of using virtual and augmented reality will be presented. NI-TS1 Theoretical Seminar Master I 7 Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TS2 Theoretical Seminar Master II Ζ Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TS3 Theoretical Seminar Master III Ζ Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TS4 Theoretical Seminar Master IV Theoretical seminar is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classical reading group. The students are treated individually and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a work with scientific papers and other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar. NI-TKA Category Theory Z,ZK 4 NI-TNN Theory of Neural Networks Z.ZK 5 In this course, we study neural networks from the point of view of the theory of function approximation and from the point of view of probability theory. At first, we recall basic concepts pertaining to artificial neural Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, network topology, somatic and synaptic mappings, network training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transformation into a canonical topology, and in connection with somatic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with training, we pay attention to the problem of overtraining and to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most important optimization methods employed for neural network training. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within the topic approximation approach to neural networks, we first notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kolmogorov theorem, Vituškin theorem). Afterwards, we will see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings computed by neural networks being dense in important Banach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to a finite measure, spaces of functions with continuous derivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expectation and training based on a random sample, and with probabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how it is possible to get an estimate of the conditional expectancy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law of large numbers and get acquainted with an analogy of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central limit theorem, get acquinted with its analogy for neural networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be employed to search for the topology of the network. NI-CPX Complexity Theory Z,ZK 5 Students will learn about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the theory concerning practical (in)tractability of difficult problems FI-TOP Academic writing Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication. Writing scientific publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone else's article. The course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. Dates will be determined based on the availability of enrolled students. NI-DVG Introduction to Discrete and Computational Geometry 7.7K 5 The course intends to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with the most fundamental notions of this discipline, and to be able to solve simple algorithmic problems with a geometric component.

NI-VOL	Elections	Z,ZK	5
We will cover the basic	s of (committee) elections and, in general, opinion aggregation.		
NI-VYC	Computability	Z,ZK	4
Classical theory of rec	ursive functions and effective computability.		•
NI-VPR	Research Project	Z	5
Student obtains the cre	edits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.		
NI-ZS10	Master internship abroad for 10 credits	Z	10
Each student can once	within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research ins	titution. Before the	e internship the
Dean of the FIT, or the	vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content an	d extent of the inte	ernship. Auxiliary
courses MI-ZS10, MI-Z	S20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 w	eeks of full-time e	mployment with

a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.

NI-ZS20 Master internship abroad for 20 credits

20

7

Ζ

Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.

NI-ZS30 Master internship abroad for 30 credits

30

The course is prezented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institution. Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and extent of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 weeks of full-time employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects if the internship exceeds the academic year's dead-line.

List of courses of this pass:

Code	Name of the course	Completion	Credits	
FI-TOP	Academic writing	Z	2	
Publishing is an important and required part of research activity. It is not only about obtaining research results but also about applying them in the form of publication. Writing scientific				
publications can be useful for students not only in their own publishing activities but also in the preparation of a bachelor's or master's thesis. In the course, students will learn how to				
write a scientific article, what parts such an article should have, and how the peer review process works. Students will also try their hand at presenting an article and reviewing someone				
else's article. The	course will be taught in blocks, with one lecture at the beginning of the semester and one practicum in the middle of the semester. Da	ates will be determ	ined based	

	on the availability of enrolled students.		
FIT-ITI	Modern IT infrastructure	Z,ZK	5
FIT-SEP	World Economy and Business	Z,ZK	4

This course is presented in Czech. The course introduces students of technical university to the international business. It does that predominantly by comparing individual countries and key regions of world economy. Students get to know about different religions and cultures, necessary for doing business in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for the right investment decision. Seminars help to improve on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course BIE-SEP as a prerequisite.

FITE-EHD Introduction to European Economic History Z,ZK

The course introduces a selection of themes from the European economic history. It gives the student basic knowledge about forming of the global economy through the description of the key periods in history. As European countries have been dominant actors in this process it focuses predominantly on their roles in the economic history. From large economic area of Roman Empire to fragmentation of the Middle Ages, from destruction of WWII to the current affairs, the development of modern financial institutions is deciphered. The course does not cover detailed economic history of particular European countries but rather the impact of trade and role of particular events, institutions and organizations in history. Class meetings will consist of a mixture of lecture and discussion.

Z.ZK NI-ADM Data Mining Algorithms

The course focuses on algorithms used in the fields of machine learning and data mining. However, this is not an introductory course, and the students should know machine learning basics. The emphasis is put on advanced algorithms (e.g., gradient boosting) and non-basic kinds of machine learning tasks (e.g., recommendation systems) and models (e.g., kernel

NI-ADP Architecture and Design patterns Z.ZK

The objective of this course is to provide students with both work knowledge about the underlying foundations of object-oriented design and analysis as well as with understanding of the challenges, issues, and tradeoffs of advanced software design. In the first part of the course, the students will refresh and deepen their knowledge of object-oriented programming and get familiar with the commonly used object-oriented design patterns that represent the best practices for solving common software design problems. In the second part the students will be introduced to the principles of software architecture design and analysis. This includes the classical architectural styles, component based systems, and some advanced software architectures used in large-scale distributed systems.

Applied Functional Programming

This course is presented in Czech. Functional programming represents one of the traditional programming paradigms. Traditional and novel functional programming languages are on the rise nowadays and the functional paradigm becomes an important construct of traditionally imperative languages (C++, C#, Java). As such, mastering this paradigm becomes a necessary competence of a software engineer: the theory and especially the practice.

NI-AIB Algorithms of Information Security Z,ZK

Students will get acquainted with the algorithms of secure key generation and cryptographic error (not only biometric) data processing. Furthermore, students will learn the mathematical principles of cryptographic protocols (identification, authentication, and signature schemes). Another part of the course is dedicated to malware detection and the use of machine learning in detection systems. The last topic includes practical steganographic methods and attacks on steganographic systems.

NI-AM1	Middleware Architectures 1	Z,ZK	5
	dy new trends, concepts, and technologies in the area of service-oriented architectures. The will gain an overview of information syste		
architecture and ap	lication servers. The will also study principles and technologies for middleware focused on application integrations, asynchronous comm of applications.	unications and nigr	n availability
NI-AM2	Middleware Architectures 2	Z.ZK	5
	new trends and technologies on the Web including theoretical foundations. They will gain an overview of Web application architecture	' '	-
Oldderits Will learn	for microservices, distrubuted cache and databases, smart contracts, realtime communication and web security.	75, concepts and te	ormologics
NI-AML	Advanced machine learning	Z,ZK	5
	ces students to selected advanced topics of machine learning and artificial intelligence. The topics present techniques in the field of rec		-
processing,	control and interconnection of physical laws with the field of machine learning. The aim of the exercise is to familiarize students with	he methods discus	sed.
NI-AOA	Completing a professional event	Z	1
The subject is parti	icipation in a one-off professional event, usually a lecture by a foreign guest of the FIT CTU, concluded with a workshop, a test, drafti	ng a report, etc.Suc	ch an event
must be approved	d in advance by the vice-dean for pedagogical activities or the vice-dean for science and research and is presented within the FIT thro	ough a website, info	omail, etc.
NI-APH	Architecture of computer games	Z,ZK	4
	basic understanding of the various issues in the field of computer games development, especially from a technical point of view, but also		
	vill get a grasp of component-oriented and functional-oriented architecture, game mechanics, decision-making processes and base co		
part of most game	es. They will also understand the basics of pathfinding, networking and scripting and apply them in practical exercises (labs). An impo implementation of a simple game, with a strong focus on nontrivial game mechanics.	riant part of the co	urse is an
NI-APR	Selected Methods for Program Analysis	Z,ZK	5
	ices you to program analysis, i.e., the automated reasoning about the behavior of a computer program. We will cover static and dynar	, ,	-
	art of reasoning about computer programs without running them. We will look at the analyses for program understanding, optimization	=	-
	Analysis, we will look at the analyses considering individual program runs using a concrete environment and inputs.		
NI-APT	Advanced Program Testing	Z,ZK	5
Testing a program	is essential to ensure that a program respects its specification, that changes do not introduce regressions or security issues. The go	al of the course is	to present
	advanced program testing techniques, beyond writing unit tests, especially fuzzing and symbolic execution.		
NI-ARI	Computer arithmetic	Z,ZK	4
	Students will learn various data representations used in digital devices and will be able to design arithmetic operations implementa		
NI-ATH	AlgorithmicTheories of Games	Z,ZK	, 4
_	theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies are competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game to		-
	s of the game where no player wants to deviate from his strategy. Due to the recent development of computers, internet, social network	· ·	
	s and other concepts the algorithmic point of view is gaining attention. In addition to existential questions we study the problems of el		- 1
solution	concepts. In this course we introduce the basics of game theory of many players, solution concept (usually equilibria) and methods of	f their computation	
NI-BKO	Error Control Codes	Z,ZK	5
	al of the course is to present various ways to detect or correct individual errors and burst errors in data stored into memories or transf	nitted via channels.	
NI-BML	Bayesian Methods for Machine Learning	KZ	5
•	sed on practical use of basic Bayesian modeling methods in the dynamically evolving machine learning theory. In particular, it studies		
	description of real phenomena, as well as their subsequent use, e.g., for forecasting of future evolution or learning about the hidden vitions etc.). The emphasis is put on understanding of explained principles and methods and their practical adoption. For this purpose, a		
•	will be presented to students, for instance, 2D/3D object tracking, radiation source term estimation, or separation in medical imaging.		
	some of them.		,
NI-BPS	Wireless Computer Networks	Z,ZK	4
Students will learn	n about the modern technologies, protocols, and standards for wireless networks. They will understand the routing mechanisms in ad	-hoc networks, mul	ticast and
broadcast mechai	nisms, and data flow control mechanisms. They will also learn about principles of communication in sensor networks. They get knowle	edge of security me	echanisms
	for wireless networks and get skills of configuration of wireless network elements and simulation of wireless networks using suitable		
NI-BUI	Business Informatics	Z,ZK	5
	se is to focus on operational, tactical and strategic management of business informatics. Students will gain knowledge in the areas of b	=	-
	architectures in enterprise informatics. They will also learn about the principles, models and standards (ITIL, COBIT) in IT manageme nd resource management (sourcing). Students will learn the process of creating and implementing information strategy, IT Governan		٠ ا
	e context of information strategy with global business strategy. They will also gain knowledge in the areas of economic IT manageme	· · · · · · · · · · · · · · · · · · ·	
	management, IT investment evaluation and human resources management in IT (roles CIO, CEO, CFO).	,	
NI-BVS	Embedded Security	Z,ZK	5
	knowledge in selected topics of cryptography and cryptanalysis. The course focuses particularly on efficient implementations of cryptography		
and software (in em	bedded systems). Students gain a good overview of functionality of (hardware) cryptographic accelerators, smart cards, and resources	for securing intern	al functions
	of computer systems.		
NI-CCC	Creative Coding and Computational Art	KZ	4
•	practical tasks, get acquainted with creative and yet proven methods of visualizing various types of data. The course freely follows the		
.,	ices students to suitable visualization methods for traditional as well as for open data. It combines well-known visualization technique es. The aim is to create an interesting visualization project. It is planned to work closely with IPR CAMP (Center of Architecture and N		٠ ا
modern teennologi	(Institute of Intermedia FEL).	ictropolitari i iariili	ng) and mivi
		7 71/	5
NI-CPX	COMORXIV INCOLV	2.ZN	
NI-CPX Students will lear	Complexity Theory or about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the	Z,ZK theory concerning	
	· · · ·		
	n about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the		
Students will lear	n about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the (in)tractability of difficult problems.	theory concerning	practical
NI-CTF NI-DDM	n about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the (in)tractability of difficult problems. Capture The Flag The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber se Distributed Data Mining	ktheory concerning KZ curity. KZ	practical 4 4
NI-CTF NI-DDM Course focuses on	n about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the (in)tractability of difficult problems. Capture The Flag The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber se Distributed Data Mining state-of-the-art approaches for distributed data mining and parallelization of machine learning algorithms. Students will gain hands of	KZ curity. KZ on experience with 1	4 4 large scale
NI-CTF NI-DDM Course focuses on	n about the fundamental classes of problems in the complexity theory and different models of algoritms and about implications of the (in)tractability of difficult problems. Capture The Flag The course is designed to introduce students to CTF competitions and let them gain practical experience in the field of cyber se Distributed Data Mining	KZ curity. KZ on experience with 1	4 4 large scale

NI-DDW	Web Data Mining	Z,ZK	5
	arn latest methods and technologies for web data acquisition, analysis and utilization of the discovered knowledge. Students will gain		
techniques for vveb	crawling, Web structure analysis, Web usage analysis, Web content mining and information extraction. Students will also gain an overview in the field of social web and recommendation systems.	w of most recent dev	/eiopments
NI-DID	Digital drawing	Z	2
	roduce students to the basic principals of digital drawing and graphical design. Students will gain understanding of composition, persp	-	
they will practically	apply in their own design works. Students will also gain experience in drawing and painting with digital and analog tools. The course	is fit for anyone who	o wants to
	r learn drawing and painting. The course is organized as a thematic practices covering parts of theory and practical exercise to practic	e gained knowledg	
NI-DIP	Diploma Project	Z	30
NI-DNP	Advanced .NET ire an overview of platform .NET and will gain knowledge about technologies ASP.NET Core, Entity Framework Core, .NET MAUI (WF	Z,ZK	4
•	re DevOps and GIT. Students will get practical experience in semestral work where they will create a client-server application utilizing Entity Framework Core and (Blazor, .NET MAUI or WPF) and also Azure DevOps and GIT.	•	
NI-DPH	Game Design	Z,ZK	5
· · · · · · · · · · · · · · · · · · ·	ements the NI-APH (Architecture of Computer Games) and BI-VHS (Virtual gaming worlds) course, while focusing primarily on game d	-	
-	per knowledge of the principles used for games design, such as: level design, gameplay design, character design, game mechanics d . The students will get an overview of game development from the designer's perspective, from theoretical concepts to practical impler		- 1
aovolopinioni oyolo	projects.	nontation applied to	Comodital
NI-DSS	Decision Support Systems	Z,ZK	5
	rse is to provide students with knowledge and skills in decision support systems, their classification (Powerova), selected principles of		
of (ented decision support systems. Students will also gain knowledge of multicriterial decision-making methods and game theory. They will conceptually and ontologically oriented decision support systems and the basics of distribution, optimization and evolution methods a		
NI-DSV	Distributed Systems and Computing	Z,ZK	5
	uced to methods for coordination of processes in distributed environment characterised by nondeterministic time responses of computing rn basic algorithms that assure correctness of computations realized by a group of loosely coupled processes and mechanisms that s		
onarmolo. Trioy loa	data and services, and safety in case of failures.	apport mgm availabl	inty or boar
NI-DSW	Design Sprint	Z	2
	on projects using the Design Sprint method, developed by Google. THanks to this method the teams are able to go from idea to validate		
	udents will get familiar with the method as participants. Through practical challenges they will try the whole 5 day process starting with testing the prototypes (plus final presentation).		hing with
NI-DVG	Introduction to Discrete and Computational Geometry	Z,ZK	5
The course intends	s to introduce the students to the discipline of Discrete and Computational Geometry. The main goal of the course is to get familiar with of this discipline, and to be able to solve simple algorithmic problems with a geometric component.	the most fundamen	ital notions
NI-DZO	Digital Image Processing	Z,ZK	4
	ents a comprehensive overview of modern methods for interactive editing of digital images and video. It mainly deals with practical alg		
-	e an interesting theoretical basis. Visually attractive applications provide better understanding of basic theoretical background that is als		
	processing. This course will introduce algorithms solving the following practical applications: edge-aware editing, tone mapping, HDR	•	- 1
interactive as-ri	abstraction, hybrid images, gradient domain editing, seamless image stitching and cloning, digital photo-montage, color-to-gray conv gid-as-possible image deformation, free-form image registration, texture synthesis, interactive segmentation, colorization, painting, ac	lding depth, alpha n	natting.
NI-EDW The Enterprise Da	Enterprise Data Warehouse Systems ta Warehouses course focuses on the area of business intelligence. Students will be introduced to business intelligence methods and	Z,ZK	5 mowledge
	ing warehouses and various architectures, but also their deployment and maintenance. This course also includes an introduction to the visualization.		
NI-EHW	Embedded Hardware	Z,ZK	5
•	s basic laws that govern digital design and basic techniques to use them. It deals with both large and small scale systems. This is the		
systems, that profit	t from their specialized structure for effective computation and acceleration. Design of fast custom computing machines is discussed, of internal communication, parallelism extraction and utilization in special structures and system architectures.	including standardiz	zed means
NI-EPC	Effective C++ programming	Z,ZK	5
	v to use the modern features of contemporary versions of the C++ programming language for software development. The course focus		-
	ficiency in the form of writing maintainable and portable source code and creating correct programs with low memory and processor t	me requirements.	
NI-ESC	Experimental Project Course	KZ	. 8
	ct course offers a holistic exploration of the design process, providing students with a well-rounded understanding of the principles, mology-driven solutions that are user-centric and industry-relevant. Throughout the semester, students will work on real-world design pro	-	
	n to integrate theory with practical application. Through a hands-on, project-based learning approach, students will develop their skills	•	- 1
• ,	user experience evaluation, as well as gain experience working in a team to design and prototype a functional solution."		
NI-ESW	Embedded Software	Z,ZK	5
	e course acquainted students with the specifics of software development for embedded systems. The course covers the areas from the ba		1
in C language an	d code optimizations, through typical areas as the reliable software development, embedded operating systems, signal processing, up combined with artificial intelligence.	to sophisticated te	cnniques
NI-EVY	Efficient Text Pattern Matching	Z,ZK	5
	edge of efficient algorithms for text pattern matching. They learn to use so called succinct data structures that are efficient in both access		
	They will be able to use the knowledge in design of applications that utilize pattern matching.		
NI-FME	Formal Methods and Specifications	Z,ZK	5
Students are able t	to describe semantics of software formally and to use sound reasoning for construction of correct software. They learn to use some software.	tware tools that allo	w to prove
NI-FMT	Finite model theory	Z,ZK	4
	rse is to introduce students to the basics of finite model theory. The original motivation is the questions expressibility and verifiability of		
	inception in the 1970s, the course has evolved rapidly and touched on many other areas of theoretical computer science, such as des		
	Constraint Satisfaction Problem (CSP), the theory of algorithmic meta-theorems and combinatorics.		
NI-GAK	Graph theory and combinatorics	Z,ZK	5
The goal of the cla		The emphasis will b	oe not only

coloring, Ramsey	theory, introduction to probabilistic method, properties of various special classes of graphs and combinatorial structures. The theory w of combinatorics on words, formal languages and bioinformatics.	vill be also applied	in the fields
NI-GEN	Code Generators	Z,ZK	5
	ques of translating programs written in high-level programming languages are essential for understanding the field of systems program		l
	algorithms and techniques used to translate more complex programming constructs of modern languages employed in systems progra	-	-
	familiar with both the theoretical and practical aspects of implementing the back-end of optimizing compilers for programming language.	guages.	
NI-GLR	Games and reinforcement learning	Z,ZK	4
The field of reinfor	recement learning is very hot recently, because of advances in deep learning, recurrent neural networks and general artificial intelligen		intended to
NII ONINI	give you both theoretical and practical background so you can participate in related research activities. Presented in English		4
NI-GNN	Graph Neural Networks oduces students to advanced artificial intelligence techniques for working with graphs. Lectures will focus on the latest graph neural n	Z,ZK	4
	oduces students to advanced artificial intelligence techniques for working with graphs, Ecctures will locus on the latest graph neural nor provided in the latest graphs. The techniques discussed cover various types of graphs, including time-varying graphs. The last p		•
.,	graph generation and interpretability of graph neural networks. In the exercises, students will try out selected techniques and pro		
NI-GOL	Programming of distributed systems in GO	KZ	5
NI-GPU	GPU Architectures and Programming	Z,ZK	5
Students will gain l	knowledge of the internal architecture of modern massively parallel GPU processors. They will learn to program them mainly in the CUI	DA programming e	nvironment,
which is already a v	widespread programming technology of GPU processors. As an integral part of the effective computational use of these hierarchical com	putational structur	es, students
	will also learn optimization programming techniques and methods of programming multiprocessor GPU systems.		_
NI-GRI	Grid Computing	Z,ZK	5
NII LICM	Grid computing and gain knowledge about the world-wide network and computing infrastructure.	ZK	E
NI-HCM	Mind Hacking is an emerging discipline that is closely related to cyber security. While the domain of cyber security is the protection of networks, info		5
	initive security is the protection of the human mind from intentional and unintentional digital manipulation. The topic of cognitive security	-	
-	mation warfare, increasing digital dependence and the development of artificial intelligence, where these phenomena from the Internet		-
	impacts such as disruption of social cohesion, threats to democracy or war.		
NI-HMI2	History of Mathematics and Informatics	ZK	3
This course is pr	resented in Czech. Selected topics (Infinitesimal calculus, probability, number theory, general algebra, different examples of algorithms		recursive
	functions, eliptic curves, etc.) note on possibilities of applications of some mathematical methods in informatics and its develop		
NI-HSC	Side-Channel Analysis in Hardware	Z,ZK	4
	edicated to so-called side-channel information leakage in hardware devices. It focuses on both theoretical analysis and practical attack	-	
	side channels and they get deeper insight in power attacks. Students learn to implement various profiled and non-profiled attacks and They also get practice in both designing the SCA countermeasures and analyzing the amount and characteristics of the side-channel	-	-
NI-HWB	Hardware Security	Z,ZK	5
	es the knowledge needed for the analysis and design of computer systems security solutions. Students get an overview of safeguards	,	_
	neans. They will be able to safely use and integrate hardware components into systems and test them for resistance to attacks. Studer		
the cr	yptographic accelerators, PUF, random number generators, smart cards, biometric devices, and devices for internal security functions	s of the computer.	
NI-IAM	Internet and Multimedia	Z,ZK	4
	se is focused on principles and modern technologies for network transmissions of audiovisual (AV) signals. The syllabus includes acq	_	
	signals (output), network communication protocols, device interfaces, codecs, data formats and stereoscopy. We will look at practical unit in a second of the control of th		
	missions. Within the labs, students will practically assemble AV transmission chains using HW and SW technologies and verify the effectory of AV transmissions. Students will learn how to build Internet infrastructure for end-to-end AV transmissions from the recording the		
irle quality and late	for audience.	e scene up to the p	Dieseritation
NI-IBE	Information Security	ZK	2
	prmation and IS/ICT security management systems (ISMS), methods for information access control, and basic norms and internation		l
understar	nd methods for management of internal and external security threats, for IS/IT security audits, and for application security testing (e.g.	, penetration testin	ıg).
NI-IKM	Internet and Classification Methods	Z,ZK	4
	students get acquainted with classification methods used in four important internet, or generally network applications: in spam filtering		-
	ion systems and in intrusion detection systems. However, they will learn more than only how classification is performed when solving		-
•	d of these applications, they get an overview of the fundamentals of classification methods. The course is taught in a 2-weeks cycle w During the exercises, the students on the one hand implement simple examples to topics from the lectures, on the other hand consul-		
NI-IOS	Advanced techniques in iOS applications	KZ	4
	the latest trends in mobile development technologies for iOS platform. Class covers advanced topics, students need to know all the based on the base of the latest trends in mobile development technologies for iOS platform.		l
	BI-IOS.	3	
NI-IOT	Internet of Things	Z,ZK	4
The subject is t	focused on the area of hardware and software technologies for the strongly growing computer support of various devices. Its goal is fa	amiliarization with a	available
	development elements (Raspberry Pi, Arduino Due) and with the language for efficient application development and modification (G	NU Forth).	ı
NI-IVS	1 (11) (1 1 1 1 (4
Intelligent embedo	Intelligent embedded systems	KZ	
ad the administration of the	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The	course is an advar	
•	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programments.	course is an advar ning and advance	application
•	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of	course is an advar ning and advance develop advanced	application
development. Lect	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programments.	course is an advar ning and advance develop advanced nologies	application
development. Lecti	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmers provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technical states.	course is an advar ning and advance develop advanced nologies Z,ZK	application applications
NI-KOD Students are intro	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technology to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students are considered as a compression methods. In addition, students are considered as a compression methods.	course is an advar ning and advance develop advanced nologies Z,ZK compression meth	application applications 5 nods being
NI-KOD Students are introused in practice. To	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technology to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students and compression methods used in image, audio, and video compression.	course is an advar ning and advance develop advanced nologies Z,ZK compression methents learn the fund	application applications 5 nods being amentals of
NI-KOD Students are introused in practice. To	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technological compression. Data Compression oduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students lossy data compression methods used in image, audio, and video compression. Combinatorial Optimization	course is an advar ning and advance develop advanced nologies Z,ZK compression methents learn the fund	application applications 5 nods being amentals of
NI-KOD Students are introused in practice. To	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technological compression. Data Compression oduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, students and compression methods used in image, audio, and video compression. Combinatorial Optimization gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only	course is an advar ning and advance develop advanced nologies Z,ZK compression methents learn the fund	application applications 5 nods being amentals of
NI-KOD Students are intro used in practice. To NI-KOP The students will	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technology to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, studently lossy data compression methods used in image, audio, and video compression. Combinatorial Optimization gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only also to apply and evaluate heuristics for practical problems.	course is an advar ning and advance develop advanced nologies Z,ZK compression methents learn the fund Z,ZK y to select and imp	application applications 5 nods being amentals of 6 olement but
NI-KOD Students are intro used in practice. To NI-KOP The students will of	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technology and compression. Data Compression Data Compression Data Compression Data Compression Data Compression Doduced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data the overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, student lossy data compression methods used in image, audio, and video compression. Combinatorial Optimization gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only also to apply and evaluate heuristics for practical problems. Advanced Cryptology	course is an advar ning and advance develop advanced nologies Z,ZK compression methents learn the fund Z,ZK y to select and imp	application applications 5 nods being amentals of 6 olement but
NI-KOD Students are intro used in practice. To NI-KOP The students will of NI-KRY Students will lear	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technology to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data he overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, studently lossy data compression methods used in image, audio, and video compression. Combinatorial Optimization gain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only also to apply and evaluate heuristics for practical problems.	course is an advarning and advance develop advanced nologies Z,ZK compression methents learn the fund Z,ZK y to select and imp	application applications 5 nods being amentals of 6 olement but 5 rinciples of
NI-KOD Students are intro used in practice. To NI-KOP The students will of NI-KRY Students will lear	ded systems course for master's degree is focused on high-level technology embedded systems integrating artificial intelligence. The embedded system fundamentals course for the bachelor degree. The aim of the course is to teach students humanoid robot programmures provide basis of motion control, sensor reading, application interfaces, robot navigation and development tools. In labs, students of combining knowledge of various courses like nature inspired algorithms, data mining algorithms, image recognition and web technology and compression. Data Compression In duced to the basic principles of data compression. They will learn the necessary theoretical background and get an overview of data the overview covers principles of integer coding and of statistical, dictionary, and context data compression methods. In addition, studenth lossy data compression methods used in image, audio, and video compression. Combinatorial Optimization Grain knowledge and understanding necessary deployment of combinatorial heuristics at a professional level. They will be able not only also to apply and evaluate heuristics for practical problems. Advanced Cryptology In the essentials of cryptanalysis and the mathematical principles of constructing symmetric and asymmetric ciphers. They will know the	course is an advarning and advance develop advanced nologies Z,ZK compression methents learn the fund Z,ZK y to select and imp	application applications 5 nods being amentals of 6 olement but 5 rinciples of

NI-KTH Combinatorial Theories of Games Z,ZK Traditional game theory is a branch of mathematics, which has broad applications in economy, biology, politics and computer science. This theory studies the behaviour of agents (players) of a certain competitive process by designinng a mathematical model and investigating the strategies. The traditional task of classical game theory is to find the equilibria, which are the states of the game where no player wants to deviate from his strategy. Historically, the second big development in game theory of two-player full-information combinatorial games, was by Conway, Berlekamp and Guy. They developed a theory, originally used for solving end-games in Go, into a full fledged field. The idea is to evaluate games such that otherwise incompatible games can be added, that is, played simultaneously. This led to the algrebraic approach to study combinatorial games. The third most important step is the work of Beck, who established the theory of positional games (like tic-tac-toe and hex). In analysis of these game, one cannot escape the brute-force traversal of the game tree, which is no efficient. Beck introduced the "false probabilistic method", which aims to tackhle this problem. In this course we build the foundation of the theory of combinatorial and positional games. We focus on theoretical analysis of games and building the theory, not on the programming aspects of game solving algorithms. The course requires independent work, ability to mathematically analyse, think and proof. The course is also suitable for bachelors student in the third year, who attended introduction to graph theory, as well as for PhD students looking for research topics. NI-KYB Cybernality ZK 5 Students get acquainted with the fundamentals of legislation and international activities in the area of fighting cybercrime. Students will understand the classification of attacks and have an overview of systems for computer surveillance and traffic monitoring in the cyberspace. Students will also familiarize themselves with hacker activities and behavior. The course will also discuss the cooperation of the state agencies and subjects dealing with defence of the cyberspace (especially CSIRT and CERT teams). NI-LOM Linear Optimization and Methods Students learn the applications of optimization methods in computer science, economics, and industry. They are aware of practical importance of linear and integer programming. They are able to work with optimization software and are familiar with languages used in programming of that software. They get skills in formalization of optimization problems in computer science (such as scheduling of tasks to processors, analysis of network flows), distribution and allocation of resources (transportation problems, travelling salesman problems, etc.), issues from economics, and modelling of conflicts via the game theory. They get an overview of computational complexity of optimization problems. They get orientation in algorithms in linear programming. NI-LSM2 Statistical Modelling Lab The topic of LSM2 is advanced multiple target tracking (MTT). This domain covers simultaneous tracking of multiple targets using radar under the presence of clutter, or video tracking We aim at the state-of-the-art filters, in particular the PHD (Probability Hypothesis Density) and PMBM (Poisson Multi-Bernoulli) filters. Multicore CPU Computing NI-MCC 5 Students will get acquainted in detail with hardware support and programming technologies for the creation of parallel multithreaded computations on multicore processors with shared and virtually shared memories, which are today the most common computing nodes of powerful (super)computer systems. Students will gain knowledge of architecturally specific optimization techniques used to reduce the performance drop due to the widening gap between the computational requirements of multi-core CPUs and memory interface throughput. On specific non-trivial multithreaded programs, students will also learn the basics of the art of creating these applications. NI-MEP Modelling of Enterprise Processes The subject is focused on introduction to the discipline of Enterprise Engineering. Students learn the importance of a proper methodological approach for (re)engineering and implementation of processes, organisation structures and information support in big enterprises and institutions. NI-MKY Mathematics for Cryptology 7.7K 5 Students will gain deeper knowledge of algebraic procedures solving the most important mathematical problems concerning the security of ciphers. In particular, the course focuses on the problem of solving a system of polynomial equations over a finite field, the problem of factorization of large numbers and the problem of discrete logarithm. The problem of factorization will also be solved on elliptic curves. Students will further become familiar with modern encryption systems based on lattices NI-MLP Machine Learning in Practice Applying machine learning methods to real projects in practice involves many other necessary tasks - from understanding the intentions of the client to, ideally, technical implementation. The course guides students through all phases of a project according to the standard CRISP-DM methodology, not only theoretically but also practically. The aim is to experience real data processing and learn how to describe the whole process from exploration to evaluation of the model performance in the form of a clear and understandable report. NI-MOP Modern Object-Oriented Programming in Pharo Object-oriented programming is currently one of the most widespread paradigms of software creation, especially enterprise information systems, where its ability to natural abstraction is used to build complex modern applications. In this course, we build on the knowledge acquired in the course BI-OOP and aim to further deepen the skills of design and implementation of object systems in modern pure object system Pharo (https://pharo.org). The course focuses on individual approach to students, their development needs and areas of interest. In addition to deepening object programming skills, which are generally applicable in other OO languages, students will also gain the opportunity to work on interesting projects and OO technologies in terms of semestral work with the possibility of cooperation with practice and related bachelor, diploma, postgraduate our direct involvement in the Pharo Consortium. Mathematics for Informatics The course comprises topics from general algebra with focus on finite structures used in computer science. It includes topics from multi-variate analysis, smooth optimization and multi-variate integration. The third large topic is computer arithmetics and number representation in a computer along with error manipulation. The last topic includes selected numerical algorithm and their stability analysis. The topics are completed with demonstration of applications in computer science. The course focuses on clear presentation and argumentation. Modelling of Programming Languages The analysis, transformation, and code generation processes depend on the semantics of the language; in particular, they are correct if they preserve the semantics of the language This course explores the semantics of programming languages. The students will learn the language models with emphasis on functional languages, students are expected to understand the basics of the lambda calculus and here get acquainted with the advanced lambda calculus. The students also get hands-on-experience with semantic modeling and execution tools. Managerial Psychology NI-MPL ZK NI-MPR Master Project 1. At the beginning of the semester, a student reserves her/his final thesis topic and gets together with its supervisor. Together they decide on partial tasks that should be carried out during the semester. If the requirements they agreed upon are met, the supervisor awards the student an assessment for the course MI-MPR at the end of the semester. 2. The external supervisor enters the information on granting the credit using the form "Granting credit from the external supervisor of the final thesis" (http://fit.cvut.cz/student/studijni/formulare). The completed and signed form must be delivered in person or by email to the SZZ coordinator, who will arrange for the credit to be granted. 3. If the FT topic that the student has reserved is rather general, the immediate tasks the supervisor assigns to the student for the upcoming semester should aim at fine-tuning the FT topic so that the FTT will be complete and approvable at the end of the semester. NI-MSI Mathematical Structures in Computer Science Mathematical semantics of programming languages. Data types as continuous lattices, Scott topology. Procedures as continuous mappings. The Scott model of lambda calculus. Introduction to category theory. Modern Internet Technologies SYNOPSIS The subject "Modern Internet Technologies" is designed on four major pillars of networking: 1. Unified Communication and Collaboration - A single network, oriented on TCP/IP is able to carry whatever types of protocols for whatever purposes. This architecture is able to be protocol independent and carries voice, video and data to achieve seamless integrated services. 2. Design of Extremely Scalable Networks - This provides the insights of network architectures which can accommodate hundreds of millions of users and billions of devices. Thus, there is a paradigm switch from LANs (Local Area Networks) to SPs (Service Providers). 3. Traffic Segregation, Traffic Matching and Traffic Prioritisation - These technologies allow service providers to create private channels of communication between customers, with guaranteed parameters (bandwidth, delay, jitter, type of protocol). 4. Acceleration Technologies - They allow traffic to be carried at the optimal speed and allow for graceful degradation of service parameters in case of failures.

NI-MVI	Computational Intelligence Methods	Z,ZK	5
Students will under	erstand methods and techniques of computational intelligence that are mostly nature-inspired, parallel by nature, and applicable to m how these methods work and how to apply them to problems related to data mining, control, intelligen games, optimizations,		/ will learn
NI-MZI	Mathematics for data science	Z,ZK	4
	ents are introduced to those fields of mathematics that are necessary for understanding standard methods and algorithms used in definition of the control of		· -
include mainly: li	near algebra (matrix factorisations, eigenvalues, diagonalization), continuous optimisation (optimisation with constraints, duality princ	ciple, gradient meth-	ods) and
NII NII NA	selected notions from probability theory and statistics.		
NI-NLM	Neural Language Models ents will learn the technical foundations of the Transformer architecture as well as the practical aspects of using language models. Th	Z	5 s is to teach
ii tiiis course, stud	students how to use language models to solve problems, make informed risk assessments, and work critically with the scientific li	-	is to teach
NI-NMS	Neural Networks, Machine Learning and Randomness	Z,ZK	4
	s, i.e. methods based on randomness, are extremely important for the construction and training of neural networks as well as a num		-
	rise "Neural networks, machine learning and randomness" will discuss in sufficient depth a number of specific types of neural networks, machine learning and randomness will discuss in sufficient depth a number of specific types of neural networks and machine learning in the final true topics it explains the general	=	·=
	Il as a number of specific stochastic methods for neural networks and machine learning. In the final two topics, it explains the general d shows that, in addition to the use of randomness in neural networks and machine learning, machine learning models, including ne		_
	of the most important applications of randomness stochastic optimization methods, which include e.g. popular evolutionary algo		
NI-NMU	New media in art and design	ZK	3
	uces students to the issue of using new media in artistic and design work. Key topics are moving image, internet, computer game are		-
ramiliarize the stud	ent with the largest possible range of creative approaches in new media. The subject emphasizes dialogue with students, especially art projects.	in lectures devoted	to specific
NI-NON	Nonlinear Continuous Optimization and Numerical Methods	Z,ZK	5
Students will be inti	roduced to nonlinear continuous optimization, principles of the most popular methods of optimization and applications of such method		olems. They
	inite element method and the finite difference method used for solving ordinary and partial differential equations in engineering. They		=
linear algebraic ed	uations that arise from discretization of the continuous problems by direct and iterative algorithms. They will also learn to implement as well as in parallel.	tnese algorithms se	equentially
NI-NSS	Normalized Software Systems	ZK	5
	the foundations of normalized systems theory that studies the evolvability of modular structures based on concepts from engineering		_
	from thermodynamics. Students will understand a set of principles that indicate where violations of stability and entropy-related issu		
	second part of the course, students learn how to construct software architectures using a set of 5 design patterns called elements. Th mation systems in terms of storing data, executing actions, workflows, connectors, and triggers, while handling violations of the stability		
unctionality of inioi	This knowledge allows students to realize new levels of evolvability in software architectures.	and entropy-related	д ринорієз.
NI-NUR	User Interface Design	Z,ZK	5
	stand the theorical background of human-computer interaction and user interface (UI) design, will learn formal description of UIs, forma		
	ocesures. They get acquainted with graphical, speech, and multimodal UIs. Thanks to the gained knowledge, the students will be abl		
NI-OLI	Linux Drivers g system is an important operating system for personal computer and also for embedded systems. Systems on chip and combining po	Z,ZK	4 and FPGAs
	ability of peripheral subsystems requiring specific software drivers. This course is an advanced course in the Linux driver developme	=	
CO	urse provides knowledge of Linux operating system architecture, principles of development of various types drivers, including practic	al experience.	
NI-OSY	Operating Systems and Systems Programming	Z,ZK	5
	system programming in UNIX environment. Emphasis is given on kernel development with focus on kernel architecture and kernel d ment, memory management, file operations and architecture of modern file systems, device drivers and network programming.The c		-
	ss, upgrades of existing kernels, kernel booting, debugging using dynamic instrumentation, and techniques to guarantee portability.		
n embedded and re	eal-time operating systems are also discussed. Theoretical and general principles are demonstrated on the LINUX kernel. Within labs	, students will work	on projects
	focused on development of LINUX kernel modules.		
NI-PAM	Efficient Preprocessing and Parameterized Algorithms	Z,ZK	4
=	optimization problems for which no polynomial time algorithms are known (e.g. NP-complete problems). Despite that it is often neces: We will demonstrate that many problems can be solved much more effectively than by naively trying all possible solutions. Often one	=	-
	nputs from practice-e.g., all solutions are relatively small. Parameterized algorithms exploit that by limiting the time complexity expone		
	the input size (which can be huge). Parameterized algorithms also represent a way to formalize the notion of effective polynomial til		-
-	ible in the classical complexity. Such a polynomial time preprocessing is then a suitable first step, whatever is the subsequent solutic eterized algorithm design methods and we will also show how to prove that for some problem (and parameter) such an algorithm (pr	-	
	will also not miss out the relations to other approaches to hard problems such as moderately exponential algorithms or approximatio	• /	i exist. We
NI-PAS	Advanced Aspects of Business	Z,ZK	4
The aim of the co	urse is to provide students with advanced (compared to the bachelor's degree) knowledge and skills needed to establish and run the		business
AU DDD	management, especially in law, administration (necessary steps and documents), business economics, foreign trade and related		
NI-PDB	Advanced Database Systems emselves in problems of evaluation and optimization of SQL queries. The next part of the course deals with new concepts of databas	Z,ZK	5 led NoSOI
	e related new data models (XML, graph databases, column databases) and languages for working with them (XQuery, XPath, CYPF		
	the course deals with performance evaluation of database machines.		•
NI-PDD	Data Preprocessing	Z,ZK	5
	repare raw data for further processing and analysis. They learn what algorithms can be used to extract information from various data s and learn the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteris		
Jenes, 610., 6	nd ream the skills to apply these theoretical concepts to solve specific problems in individual projects - e.g., extraction of characteris pages.	acconominayes of	HOIH WED
NI-PDP	Parallel and Distributed Programming	Z,ZK	6
21st century in co	mputer architectures is primarily influenced by the shift of the Moore's law into parallelization of CPUs at the level of computing cores	s. Parallel computing	
_	biquitous commodity and parallel programming becomes the basic paradigm of development of efficient applications for these platfor	=	-
	es of parallel and distributed computing systems, their models, theory of interconnection networks and collective communication ope parallel programming of shared and distributed memory computers. They get acquianted with fundamental parallel algorithms and or		•
	s of design of efficient and scalable parallel algorithms and methods of performance evaluation of their implementations. The course	· · · · · · · · · · · · · · · · · · ·	=
	practical programming in OpenMP and MPI for solving a particular nontrivial problem.		

NI-PG1 Computer Grafics 1 ZK The course builds on graphic courses (mainly BI-PGA and BI-PGR) and the knowledge from these courses is deepened by state-of-the-art knowledge. The course is designed for those interested in advanced computer graphics. Students will gain practical knowledge with realistic texturing and raytracing methods. An integral part of the course is the study of scientific articles and their subsequent implementation. The course will be followed by a course PG2 supplementing the knowledge of PG1 on other areas and topics of computer graphics. NI-PIS **Enterprise Information Systems** Z,ZK 5 The course is focused on the current IT requirements of large companies in the Czech Republic (Top 100). The basis is Data management, storage of big data (BigData) and their use in BI (Business Intelligence). The principles of solving the overall architecture of information systems in the banking, insurance and telecommunications sectors will be explained on real examples. Furthermore, students will get acquainted with the life cycle of information systems in the company / organization and its impact on the business strategy of the company. Students will be acquainted with technologies that have proven themselves in the elimination of basic risks in the planning, implementation and operation of information systems in the company / organization. NI-PIV Computer Vision The Computer Vision course focuses on the theoretical and practical mastery of modern methods and algorithms in the field of image data processing. Students will get acquainted with the basic principles of computer vision, gradually move to advanced computer vision techniques using deep learning. Emphasis is placed on theoretical knowledge as well as on practical applications and implementation of learned methods during exercises. Topics covered include morphological operations, image filtering, color representations, object detection and recognition and segmentation through classical and recent approaches based on deep learning, deep neural networks for computer vision (including CNN, RCNN, YOLO, ViT), motion detection, visual expressiveness (saliency). NI-PLS1 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. NI-PLS3 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages NI-PLS4 Programming Language Seminar The Programming Language Seminar aims to introduce students to research in programming languages. It has the format of a reading group in which we discuss scientific papers about programming languages and related fields. Participating students are expected to present a paper of their interest and actively participate in the discussions. The reading group is a joint venue between FIT and MFF CUNI. It is open to all students and researchers interested in programming languages. NI-PON Selected Topics in Optimization and Numerical mathematics Z.ZK The course focuses on optimization problems that appear in the field of machine learning and artificial intelligence. Students broaden their knowledge of continuous optimization obtained in the course Mathematics for informatics. The methods are explained and described along with the details on how they are implemented on computers. Hence, the relevant concepts of numerical matematics, mainly numerical linear algebra, are explained too. NI-PSD Public Services Design ΚZ 4 The course will introduce students to specifics of UX, Service design and development for public sector. We will look into the design and development process from the perspective of suppliers (devs and designesr) as well as clients. In small teams students will work on projects from partner organizations and will try out collaboration with client representatives. Course is aimed at students-designers as well as clients. NI-PSL Programming in Scala Z,ZK 4 The course introduces the modern programming language Scala which exploits object-functional paradigm. Scala comprises advance language features - e.g.pattern matching and advance standard library. Scala enables to use of applications functional patterns e.g. H-List, Monads, etc. Scala is used by many powerful frameworks and libraries e.g. Play, Cassandra, Scalaz, etc. NI-PVR Advanced Virtual Reality The course introduces advanced parts of the virtual reality. It is a continuation of the already running graphic objects, especially the creation of 3D models in Blender, and among other things, it introduces students to their application in virtual reality. Lectures will focus on virtual reality technology, its use in various applications and will also deal with creating applications in available 3D engines (mainly Unity3D). The course is freely connected with the subject VHS (virtual game worlds), students will be able to apply the knowledge gained in this subject in virtual reality, or directly create a complex game for VR. NI-PVS Advanced embedded systems Z.ZK The course is focused on ARM processors and microcontrollers and their usage in wide range of applications. The course includes a series of advanced topics like security support, working with mass storage devices, motor control, system control and industrial communication. The students obtain both theoretical and also practical experiences with embedded systems. NI-PYT Advanced Python K7 The goal of this course is to learn various advanced techniques and methods in Python. The course indirectly continues where Programming in Python (BI-PYT) left of. The course is very hands-on and it has only tutorials, everything is demonstrated on examples. Classification is based on work in class as well as semestral coursework. The course is lead by external teachers from Red Hat. NI-REV Reverse Engineering Z,ZK 5 Students will get acquainted with the essentials of reverse engineering of computer software. They will learn how processes start and what happens before and after the main function is called. Students will understand how executable files are organized and how they interact with 3rd party libraries. Another part of the course is dedicated to reverse engineering of applications written in C++. Students will also understand principles of disassemblers and obfuscation techniques. A part of the course will also be dedicated to debuggers: how debuggers and debugging work and which methods can be used to detect it. One of the lectures will be dedicated to the latest trends on the computer malware scene. The focus of the course is on the seminars, where students will solve practically oriented tasks from the real world. Pattern Recognition The aim of the module is to give a systematic account of the major topics in pattern recognition with emphasis on problems and applications of the statistical approach to pattern recognition. Students will learn the fundamental concepts and methods of pattern recognition, including probability models, parameter estimation, and their numerical aspects NI-RUB Programming in Ruby K7 This course is presented in Czech. NI-RUN Runtime Systems Z,ZK 5 This course is an introduction to the world of virtual machines (VM) for high-level programming languages. There are two goals: Give you hands-on experience in design and implementation of a compiler and a VM from scratch, including Abstract Syntax Tree (AST) interpretation Byte code (BC) design and interpretation AST to BC compilation Memory management

Just-in-time compilation and s	ome optimization techniques Through a series of guest lectures, introduce you to various advanced topics and implementatio Dynamic optimizations, speculations, and deoptimizations Language implementation frameworks Read-world VMs	ns of real-world VM	s, including
NI-SBF	System Security and Forensics	Z,ZK	5
-	th aspects of system security (principles of end station security, principles of security policies, security models, authenticat		
students will get familiar with	forensic analysis as a tool for investigating security incidents (techniques used by malicious software/attackers and forensi importance of operating system/operating system artifacts or file system for attack analysis and detection).	c analysis techniqu	ies and the
NI-SCE1	Computer Engineering Seminar Master I	Z	4
	gineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to		-
are approached individually	within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the	subject is work wit	h scientific
articles and other professiona	al literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher	s. The topics are no	ew for each
NII COEO	semester.	7	
NI-SCE2	Computer Engineering Seminar Master II gineering is a (s)elective course for students who want to deal with deeper topics of digital design, reliability and resistance to	Z failures and attack	4 s Students
•	within the subject. Each student or group of students solves some interesting topic with the selected supervisor. Part of the		
articles and other professiona	al literature and/or work in K N laboratories. The capacity of the subject is limited by the possibilities of the seminar teacher	s. The topics are n	ew for each
	semester.		
NI-SCR	Statistical Analysis of Time Series	Z,ZK	5 Lindustrial
-	ractical use of the basic time series modelling theory in engineering tasks, ranging from economics (stock exchange prices s and processes) to computer networks (network components load, attacks detection). The students learn to select a conve		
	operties and use it for forecasting of future or intermediate values. The stress is put on understanding and adoption of the mai	•	
real-world examples. Both the	e lab classes and the lectures exploit freely available software packages in order to provide easy and straightforward transfe	er of students' know	vledge from
NII 055	the academic to the real world.	7 714	
NI-SEP	World Economy and Business	Z,ZK	4
	n Czech. However, there is an English variant in the program Informatics (N1801 / 4793). The course introduces students o es that predominantly by comparing individual countries and key regions of world economy. Students get to know about dif		-
	in diverse societies as well as indexes of economic freedom, corruption and economic development, which are needed for	•	
Seminars help to improve	on the knowledge in the form of discussions based on individual readings. It is advised to take bachelor level of this course	BIE-SEP as a prer	equisite.
NI-SIB	Network Security	Z,ZK	5
NI-SIM	Digital Circuit Simulation and Verification	Z,ZK	5
The aim of the course is to a	equaint the students with principles of digital circuit simulation at RTL (Register Transfer Level) and TLM (Transaction Level properties of proper tools. The course covers recent verification methods, too.	wodeling) levels a	na with the
NI-SWE	Semantic Web and Knowledge Graphs	Z,ZK	5
	nost recent concepts and technologies of the Semantic Web. The course will provide an overview of the Semantic Web tech		-
practices for modelling, into	gration, publishing, querying and consumption of semantic data. The students will also gain skills in creation of knowledge	graphs and their s	ystematic
NII OVD	quality assurance.	7 71/	
NI-SYP	Parsing and Compilers howledge of fundamentals of automata theory, formal language and formal translation theories. Students gain knowledge of va	Z,ZK	5 applications
The module builds upon the K	of LR parsing and are introduced to special applications of parsers, such as incremental and parallel parsing.	nous variants and t	арриовного
NI-SZ1	Knowledge Engineering Seminar Master I	Z	4
· · · · · · · · · · · · · · · · · · ·	resent a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research		
Additionally, you will learn how	v to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machin	e learning and AI o	onferences
NI-SZ2	and summer schools, as well as FIT's own Summer Research Program (VyLet). Knowledge Engineering Seminar Master II	Z	4
	resent a research paper from a top institute / research group to your peers. You will learn what is being cooked in top research		
	v to properly present and read scientific papers. The work in the seminar will prepare you to attend (and profit from) top machin		
	and summer schools, as well as FIT's own Summer Research Program (VyLet).		
NI-TES	Systems Theory	Z,ZK	5
	ability to develop systems of incredible complexity (e.g., trains, microprocessors, airplanes, nuclear power plants). However se correct behavior of a given system have become critical. A key technique for mastering this complexity is the usage of m		
	are important for the task at hand, and automated tools for analyzing those models. This subject will present theory and alg		-
	the modeling and analysis of complex systems.		
NI-TKA	Category Theory	Z,ZK	4
NI-TNN	Theory of Neural Networks	Z,ZK	5
	al networks from the point of view of the theory of function approximation and from the point of view of probability theory. At Networks, such as neurons and connections between them, types of neurons from the point of view of signal transmission, i		-
· -	training, and the role of time in neural networks. In connection with network topology, we get acquainted with its transforma		
· · · · · · · ·	atic and synaptic mappings, with their composition into mappings computed by the Network, Finally in connection with train		1
· -	to the fact that training is actually a specific optimization task, recalling the most typical objective functions and the most im	•	
	raining. We will see the meaninig of all these concepts in the context of common kinds of forward neural networks. Within the t notice the connection of neural networks to expressing functions of many variables using functions of fewer variables (Kol		
	see how the universal approximation capacity of neural networks can be mathematically formalized as the sets of mappings		
·	anach spaces of functions, in particular in the spaces of continuous functions, spaces of functions integrable with respect to		
	rivatives, and Sobolev spaces. Within the topic probabilistic approach, we first get acquainted with training based on expect	_	
	pabilistic assumptions about training data with which those two kinds of neural networks can be employed. We will see how i ncy of network outputs conditioned by its inputs using the expectancy based learning. We recall the strong and the weak law	· -	
	of the strong law of large numbers for neural networks and with the assumptions for its validity. Finally, we recall the central	=	- 1
	networks, with the assumptions for its validity and with the hypothesis tests based on it. We will see how those tests can be	-	
	topology of the network.		
NI-TS1	Theoretical Seminar Master I	Z	4
	ed for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classic oncern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v		
	other scholarly literature. The capacity is limited by the potentials of the teachers of the seminar.	Colonalo	,

NI-TS2	Theoretical Seminar Master II	Z	4
	r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classic ally and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v		
are treated individu	other scholarly literature. The capacity is limited by the potentials of the teachers of the seminar.	WORK WILLT SCIENTIFIC	papers and
NI-TS3	Theoretical Seminar Master III	Z	4
	r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classic		
are treated individu	ally and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a vother scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.	work with scientific	papers and
NI-TS4	Theoretical Seminar Master IV	Z	4
_	r is intended for students which want to come in deeper contact with contemporary theoretical computer science. It is mostly a classic	ا al reading group. T	he students
are treated individu	ally and concern themselves with interesting topics from the latest research in the area. Therefore, an integral part of the course is a v	work with scientific	papers and
NI-TSP	other scholarly literature. The capacity is limited by the the potentials of the teachers of the seminar.	Z.ZK	5
	Testing and Reliability knowledge about circuit testing and about methods for increasing reliability and security. They will get practical skills to be able to prep	,	-
-	ensitization and to use an ATPG for automatic test generation. They will be able to design easily testable circuits and systems with but		
= 0.1./	will be able to compute, analyze, and control the reliability and availability of the designed circuits.		
NI-TSW	Software Product Development The course is presented in Czech.	KZ	4
NI-TVR	Virtual Reality Technology	Z,ZK	3
	troduced to the basic concepts of virtual reality. Techniques for displaying virtual worlds (CAVE, HMD,) and the possibilities of control		-
tracking, hand tra	cking, eye tracking) will be discussed. Furthermore, the concepts of mixed and augmented reality will be introduced. Finally, ways of	using virtual and a	ugmented
NI-UMI	reality will be presented.	7 71/	
	Artificial intelligence s search and inference algorithms in major formal paradigms used in artificial intelligence such as logic theories, constraint programm	Z,ZK ning and automated	5 d planning.
	The main principles and practical applications of discussed techniques will be illustrated.	3	
NI-VCC	Virtualization and Cloud Computing	Z,ZK	5
ŭ	n knowledge of architectures of large computer systems that are used in data centers and computer infrastructure of companies and	•	<i>,</i> ,
-	rtualization principles, tools and technologies that serve to facilitate and automate configuration, testing and monitoring, and to efficie rameters of modern computer systems. Theoretically and practically, they will get acquainted with containerization as the most effecti		·
	mplex computer systems and with specific technologies of cloud systems. Finally, they will learn the principles and gain practical skills in	• • • • • • • • • • • • • • • • • • • •	·
	and development tools (Continuous integration and development).		
NI-VGA	Video Games Architecture a wide range of topics, procedures and methodologies related to the development of computer games - from a technical point of vie	Z,ZK	5 design and
	of view. In the lectures, students will be guided through the history of development, the structure of game engines, component and fu		
	, physics, graphics, artificial intelligence and multiplayer. The exercises will then cover selected technological topics in greater detail, in		
NII \ / N 4 N 4	some game mechanics, in the form of practical demonstrations.	7 71/	
NI-VMM The student obtains	Retrieval from Multimedia s general knowledge regarding interfaces of portals providing multimedia content, the principles of similarity search, the methods of feat	Z,ZK	5 multimedia
	objects, indexing, and structure of distributed search engines.		a.a.
NI-VOL	Elections	Z,ZK	5
NII VIDD	We will cover the basics of (committee) elections and, in general, opinion aggregation.		
NI-VPR	Research Project Student obtains the credits for published scientific outputs. The details are at https://courses.fit.cvut.cz/NI-VPR/en.	Z	5
NI-VSM	Selected statistical Methods	Z,ZK	7
The course leads	the student through advanced probabilistic and statistical methods used in information technology praxis. Particularly it deals with mu	ıltivariate normal d	
application of ent	ropy in coding theory, hypothesis testing (T-tests, goodness of fit tests, independence test). Second part of the course deals with rand	lom processes with	n focus on
NI-VYC	Markov chains. The high point of the course is the Queuing theory and its application in networks. Computability	Z,ZK	4
IVI-VIO	Classical theory of recursive functions and effective computability.	۷,۷۱۲	7
NI-ZS10	Master internship abroad for 10 credits	Z	10
	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institu		· ·
	the vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and ex MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 week		
	on. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects		- 1
	academic year's dead-line.		
NI-ZS20	Master internship abroad for 20 credits	Z	20
	once within his / her master's degree have a foreign internship at a foreign university or other foreign scientific and/or research institu The vice-dean for study affairs assesses the professional content. The student must provide evidence of the professional content and ex		
	MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KOS. Every 10 credits correspond to 4 week		
a foreign institution	on. The maximum number of credits a student can earn for one internship is 30 credits. This amount can be divided into two subjects	if the internship ex	ceeds the
NI 7020	academic year's dead-line. Mactor interpolain abroad for 20 credits	Z	20
NI-ZS30 The course is prez	Master internship abroad for 30 credits ented in chzech language. Each student can once within his / her master's degree have a foreign internship at a foreign university or		30 htific and/or
	Before the internship the Dean of the FIT, or the vice-dean for study affairs assesses the professional content. The student must provide	-	
	of the internship. Auxiliary courses MI-ZS10, MI-ZS20, MI-ZS30 are used used for the evidence and evaluation of the internship in IS KO		•
to 4 weeks of full-t	ime employment with a foreign institution. The maximum number of credits a student can earn for one internship is 30 credits. This ar subjects if the internship exceeds the academic year's dead-line.	nount can de divid	eu into two
NIE-BLO	Blockchain	Z,ZK	5
Students will under	stand the foundations of blockchain technology, smart contract programming, and gain an overview of most notable blockchain platforn	ns. They will be abl	e to design,
	secure decentralized application, and assess whether integration of a blockchain is suitable for a given problem. The course places a		
relationship betwe	en blockchains and information security. It is concluded with a defense of a research or applied semester project, which prepares the supervising implementation of blockchain-based solutions in both academia and business.	students for imple	menung of

NIE-PDL	Practical Deep Learning	KZ	5
This course is designed to provide students with a comprehensive understanding of Deep Learning using PyTorch, a popular open-source machine learning framework. Throughout			
the course, students will develop practical skills in building and training deep neural networks, using PyTorch to solve real-world problems in fields such as computer vision and natural			
language processing.			
NIE-PML	Personalized Machine Learning	Z,ZK	5
Personalized machine learning (PML) is a sub-field of machine learning that aims to create models and predictions based on the unique characteristics and behaviors of individual			
entities. While PML is commonly used in applications such as recommender systems, which recommend items to users based on their personal interests, its principles can be applied			
to a wide range of other fields, including education, medicine, and chemical engineering. In this course, we will explore the latest PML methods from theoretical, algorithmic, and practical			
perspectives. Specifically, we will focus on cutting-edge models that are of interest to both the research and commercial communities.			
PI-SCN	Seminars on Digital Design	ZK	4
This subject deals with problems of realization and implementation of digital circuits - both combinational and sequential. Basic means of description of digital circuits and basic logic			
synthesis and optimization algorithms are described. Basics of EDA (Electronic Design Automation) systems are given, together with combinatorial problems emerging in EDA.			

For updated information see http://bilakniha.cvut.cz/en/FF.html Generated: day 2025-07-03, time 22:08.