Course description

Department/Unit /	KIV / PPR			**Academic Year**	2023/2024	
Title	Parallel Programming			**Type of completion**	Exam	
Accredited/Credits	Yes, 6 Cred.			**Type of completion**	Combined	
Number of hours	Lecture 4 [Hours/Week] Tutorial 1 [Hours/Week]					
Occ/max	Status A	Status B	Status C	**Course credit prior to**	YES	
Summer semester	0 / -	0 / -	0 / -	**Counted into average**	YES	
Winter semester	15 / -	4 / -	0 / 10	**Min. (B+C) students**	10	
Timetable	Yes			**Repeated registration**	NO	
Language of instruction	Czech, English			**Semester taught**	Winter semester	
Optional course	Yes			**Internship duration**	0	
Evaluation scale	1|2|3|4			**Ev. sc. – cred.**	S|N	
No. of hours of on-premise						
Auto acc. of credit	No					
Periodicity	K					
Substituted course	None					
Preclusive courses	KIV/PPR-E					
Prerequisite courses	N/A					
Informally recommended courses	KIV/OS and KIV/PC and KIV/CPP					
Courses depending on this Course	KIV/DISZ, KIV/PES, KIV/RSSZ, KIV/SDSZ, KIV/SZD, KMA/PNM					

Course objectives:

To students, in theory and practice to closely introduce methods of parallel programming for systems with shared and distributed memory and real-time systems. To cover parallel applications, means for their development and runtime.

Requirements on student

Credit will be given for semestral work, midterm, and final presentation. Regular deadline: the semestral work has to be deliverd two weeks before the final presentation. Hard-deadline: the semestral work has to be delivered until 31.1. of the present academic year.

Content

1. Definitions, architectures, taxonomy, markers
2. Forms of interaction and sharing, granularity, computing models, temporal logic
3. Instruction-level paralelism
4. Threads, atomic synchronization, spurious wake-up, escape analysis, Rendez-Vous
5. C++14 multihreading
6. Intel Threading Building Blocks - task stealing scheduler
7. GPGPU - OpenCL, C++AMP, CUDA
8. OS API - WinAPI, POSIX
9. Distributed computing - topology, wormhole switching, computing models, Lamport
10. MPI - communicator, data types, persistent communication, group and reduction operations, files
11. Advanced techniques of distributed computing
12. Big Data & Cloud Computing

Fields of study

Guarantors and lecturers

- **Guarantors:** Doc. Ing. Tomáš Koutný, Ph.D. (100%)
- **Lecturer:** Doc. Ing. Tomáš Koutný, Ph.D. (100%)
- **Tutorial lecturer:** Doc. Ing. Tomáš Koutný, Ph.D. (100%)

Literature

- **Basic:** Peter Sanders, Kurt Mehlhorn, Martin Dietzfelbinger. *Sequential and Parallel Algorithms and Data Structures: The Basic Toolbox*. 2019. ISBN 978-3030252083.
- **Extending:** Björn Andrist, Viktor Sehr. *C++ High Performance: Master the art of optimizing the functioning of your C++ code*. 2020. ISBN 978-1839216541.
- **Extending:** Dahlia Malkhi. *Concurrency: The Works of Leslie Lamport*. 2019. ISBN 978-1450372701.
- **Extending:** Ali Sunyaev. *Internet Computing: Principles of Distributed Systems and Emerging Internet-Based Technologies*. 2020. ISBN 978-3030349561.
- **Recommended:** James Reinders, Ben Ashbaugh, James Brodman, Michael Kinsner, John Pennycook, Xinmin Tian. *Data Parallel C++: Mastering DPC++ for Programming of Heterogeneous Systems using C++ and SYCL*. 2020. ISBN 978-1484255735.
- **Recommended:** Rob H. Bisseling. *Parallel Scientific Computation: A Structured Approach Using BSP*. 2020. ISBN 978-0198788355.

Time requirements

All forms of study

Activities	Time requirements for activity [h]
Graduate study programme term essay (40-50)	52
Preparation for an examination (30-60)	104
Total:	**156**

assessment methods

Knowledge - knowledge achieved by taking this course are verified by the following means:

Written exam

Seminar work

Combined exam

Group presentation at a seminar

Skills - skills achieved by taking this course are verified by the following means:

Seminar work

Group presentation at a seminar

Individual presentation at a seminar

Combined exam

Competences - competence achieved by taking this course are verified by the following means:

Written exam

Combined exam

prerequisite

Knowledge - students are expected to possess the following knowledge before the course commences to finish it successfully:

aplikovat znalosti základů operačních systémů

aplikovat základní znalosti počítačových sítí

používat funkce operačního systému pro práci s vlákny

Skills - students are expected to possess the following skills before the course commences to finish it successfully:

nainstalovat a použít knihovnu jiného vývojáře

programovat v pointerovém jazyce, např. C či C++

Competences - students are expected to possess the following competences before the course commences to finish it successfully:

N/A

teaching methods

Knowledge - the following training methods are used to achieve the required knowledge:

Lecture supplemented with a discussion

Self-study of literature

Task-based study method

Skills - the following training methods are used to achieve the required skills:

Students' portfolio

Individual study

Competences - the following training methods are used to achieve the required competences:

Lecture supplemented with a discussion

learning outcomes

Knowledge - knowledge resulting from the course:

orientovat v technologiích pro paralelní výpočty

popsat možnosti paralelizace kódu pro SMP

popsat možnosti paralelizace pro CPU+GPGPU

popsat možnosti paralelizace pro MPI

popsat principy a vlastnosti paralelních a distribuovaných systémů, včetně plánování, koordinace, synchronizace a komunikace procesů, a způsoby komunikace běžnými síťovými protokoly

Skills - skills resulting from the course:

rozhodnout se, jakou technologii použít pro vývoj paralelního programu

vytvořit paralelní program pro alespoň dva ze tří následujících scénářů: SMP, CPU+GPGPU a MPI

Competences - competences resulting from the course:

N/A

Course is included in study programmes:

Study Programme	Type of	Form of	Branch	Stage	St. plan v.	Year	Block	Status	R.year	R.
Computer Science and Engineering	Postgraduate Master	Full-time	Medical Informatics	1	2020	2023	Povinné předměty	A	2	ZS
Computer Science and Engineering	Postgraduate Master	Full-time	Software Engineering	1	2020	2023	Oborové povinné předměty	A	2	ZS
Computer Science and Engineering	Postgraduate Master	Combined	Software Engineering	1	2020	2023	Oborové povinné předměty	A	2	ZS
Computer Science and Engineering	Postgraduate Master	Full-time	Software Engineering	1	2021	2023	Oborové povinné předměty	A	2	ZS
Distribuované výpočetní systémy	Postgraduate Master	Full-time	Distribuované systémy	1	2022 akr	2023	Povinné předměty	A	2	ZS
Distribuované výpočetní systémy	Postgraduate Master	Full-time	Výpočetní technika	1	2022 akr	2023	Povinné předměty	A	2	ZS

Study Programme	Type of	Form of	Branch	Stage	St. plan v.	Year	Block	Status	R.year	R.
Informatika a její specializace	Postgraduate Master	Full-time	Medicínská informatika	1	2022 akr	2023	Povinné předměty společné	A	2	ZS
Informatika a její specializace	Postgraduate Master	Full-time	Počítačová grafika	1	2022 akr	2023	Povinné předměty společné	A	2	ZS
Informatika a její specializace	Postgraduate Master	Full-time	Zpracování přirozeného jazyka	1	2022 akr	2023	Povinné předměty společné	A	2	ZS
Computer Science and Engineering	Postgraduate Master	Full-time	Computer Engineering and Networks	1	2019	2023	Specializační povinně volitelné předměty	B	2	ZS
Computer Science and Engineering	Postgraduate Master	Full-time	Computer Engineering and Networks	1	2019	2023	Specializační povinně volitelné předměty	B	2	ZS
Computer Science and Engineering	Postgraduate Master	Full-time	Computer Graphics	1	2018	2023	Povinně volitelné předměty	B	2	ZS
Softwarové a informační systémy	Postgraduate Master	Full-time	Softwarové a informační systémy	1	2022 akr	2023	Profilující základ	B	2	ZS
Applied Mechanics	Postgraduate Master	Full-time	Biomechanika a mechanika moderních materiálů	1	2018 akr	2023	Volitelné předměty - specializace (doporučené)	C	2	ZS
Applied Mechanics	Postgraduate Master	Full-time	Dynamika konstrukcí a mechatronika	1	2018 akr	2023	Volitelné předměty - specializace (doporučené)	C	2	ZS
Applied Mechanics	Postgraduate Master	Full-time	Výpočty a design konstrukcí	1	2018 akr	2023	Volitelné předměty - specializace (doporučené)	C	2	ZS