Technology
Arts Sciences
TH Köln

# Course
# PPRA - Parallel Programming and Computerarchitektur

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## General information

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|---|---|
| **Long name** | Parallel Programming and Computerarchitektur |
| **Approving CModule** | PPRA_BaTIN |
| **Responsible** | Prof. Dr. Lothar Thieling<br>Professor Fakultät IME |
| **Level** | Bachelor |
| **Semester in the year** | summer semester |
| **Duration** | Semester |
| **Hours in self-study** | 60 |
| **ECTS** | 5 |
| **Professors** | Lehrbeauftragte(r) / Thieling |
| **Requirements** | basic skills in procedural programming<br>basic skills in programming multiple tasks<br>structure and mode of operation of a simple computer<br>basics in digital systems (Automata, Hardware Description Language) |
| **Language** | German |
| **Separate final exam** | Yes |

### Final exam

#### Details

The students should demonstrate the following competencies in a written exam:

The students should demonstrate the following skills in a written exam: 1.) Confident handling of basic terms, mechanisms and concepts. 2.) Parallel

programming using common design tools (e.g. MPI and CUDA). 3.) Development of problem solutions that are predestined for the use of parallel computer systems.

### Minimum standard

At least 50% of the total number of points

### Exam Type

The students should demonstrate the following competencies in a written exam:

The students should demonstrate the following skills in a written exam: 1.) Confident handling of basic terms, mechanisms and concepts. 2.) Parallel programming using common design tools (e.g. MPI and CUDA). 3.) Development of problem solutions that are predestined for the use of parallel computer systems.

## Lecture / Exercises

### Learning goals

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#### Knowledge

basics of parallel programming
introduction
approach/basic idea
Data dependencies and synchronization
Parallel computer architectures
classification
MMID
SIMD

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design of parallel programs
development process
decomposition pattern
completely parallel
task parallelism (incl. task pool)
divide and conquer
pipeline (or general task graph)
data parallel (geometric data)
recursive data

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design of parallel programs
design pattern for parallel programming
master slave (master worker)
fork and join
single program multiple data (SPMD)
multiple program multiple data (MPMD)
map reduce
loop parallelism
mapping of program structure patterns to decomposition patterns

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design of parallel programs
performance Metrics
speedup
amdahl's law
efficiency
scalability
loss of performance
load balancing
performance measurement

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classification of standard libraries with regard to the preceding design options and their use based on design patterns
MPI (distributed memory)
CUDA (GPU programming)

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computer architectures (according to Von-Neumann)
conceptual components to increase performance regarding ...
storage
processing units
GPU (see above)
communication
protection

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implementation of the above concepts in concrete computer architectures
IA32e (AMD64)
ARM

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alternative architectures in addition to von-neuman
connection of FPGAs to von veumann architectures
veural networks implemented in FPGAs

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### Skills

The students are able to
- discuss the structure, organization and operating principle of computer systems,
- analyze the connection between hardware concepts and the effects on the software, to be able to create efficient programs,
- to understand and apply the basic principles of design from the understanding of the interactions of technology, computer concepts and applications,
- evaluate and compare computer concepts.

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The students are able to
- describe architectural features of parallel computers,
- evaluate parallel computers, programming paradigms and design patterns and select them for a specific application,
- to program parallel computers

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specifying system behavior (derived from text documents)

## Expenditure classroom teaching

| Type | Attendance (h/Wk.) |
| --- | --- |

| | |
|---|---|
| Lecture | 2 |
| Exercises (whole course) | 1 |
| Exercises (shared course) | 1 |
| Tutorial (voluntary) | 0 |

### Separate exam

none

## Practical training

### Learning goals

**Skills**

refer to "Vorlesung/Übung->Lernziele->Fertigkeiten"

targeted use of the software development environment

manage complex tasks as a small team

Development of more complex solutions to problems in the field of compute/data intensive algorithm, signal processing or artificial intelligence or graphic animation that are specific for the use of parallel computers.

### Expenditure classroom teaching

| Type | Attendance (h/Wk.) |
|---|---|
| Practical training | 1 |
| Tutorial (voluntary) | 0 |

### Separate exam

none