

A New Module in High-Performance Computing at Master Level Studies in Computing and Control

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16th Workshop DAAD

Agenda

- Motivation
- General Structure of M.Sc. Level Studies
- HPC Structure
- Final Words

Motivation

- **High Performance Computing (HPC)**
 - emerging education and research area in Computer Science (CS) and Computer Engineering (CE)
- Mostly, in support of other CS & CE disciplines
 - Applied CS, Informatics, Software Engineering (SE)
 - Embedded Systems, Control Systems, Geomatics
 - Data Science, Information Engineering
 - coverage of both **alphanumeric** and **visual data processing** applications
- **A lack of well educated experts**
 - capable of covering HPC in all necessary disciplines and applications



Motivation

- HPC is **still not well covered** by Serbian universities
 - despite that all institutions offer very good basics for HPC in their B.Sc. and M.Sc. study programs
- A new, promising initiative – **Faculty of Science of University of Novi Sad**
 - Data Science – a new module at M.Sc. Program in Applied Mathematics, from October 2016, profiles:
 - **Data Analytics**
 - **HPC**
- Dilemma: Should it be M.Sc. in Mathematics (as it is now) or CS?



Motivation

- New initiative at the Faculty of Technical Sciences (FTS) of the University of Novi Sad
 - **New module in HPC**
 - at M.Sc. level studies



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General Structure of M.Sc. Level Studies

- FTS: 4 years (B.Sc.) + 1 year (M.Sc.)
- **M.Sc. Study program in Computing and Control**
 - 60 ECTS
- 1st Semester:
 - 5 courses 3+3, each 6 ECTS
- 2nd Semester:
 - 1 course 3+3, 6 ECTS
 - Professional Practice Work, 0+3, 4 ECTS
 - Study Research Work for M.Sc. Thesis, 0+13, 10 ECTS
 - M.Sc. Thesis Work, 10 ECTS



General Structure of M.Sc. Level Studies

- **M.Sc. Study program in Computing and Control**
- A large selection of courses
 - over 60 courses in various areas of Computing and Control
 - even with a possibility to select some courses from other study programs at FTS
- **Three main areas**
 - Computer Engineering and Computer Communications
 - Control Systems and Geomatics
 - Applied CS and Informatics



General Structure of M.Sc. Level Studies

- **Applied CS and Informatics**
- Currently, a selection of 5 modules
 - M1: E-Business Systems
 - M2: Software Engineering
 - M3: Intelligent Systems
 - M4: Graphics and Multimedia Systems
 - M5: Information System Engineering
- A new module proposal
 - **M6: High Performance Computing**



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HPC Structure

Year V – M.Sc., Comp. and Control – ACS&I, HPC	Sem.	Class / Week
Parallel and Distributed Architectures and Languages	1	3+3
Parallel and Distributed Algorithms and Data Structures	1	3+3
High Performance Computer Systems	1	3+3
Architectures of Big Data Systems	1	3+3
Cloud Computing	1	3+3
Elective Course 1	2	3+3
- High Performance Computing in Scientific Computing		
- High Performance Computing in Information Engineering		
Professional Practice Work	2	0+3
Study Research Work for M.Sc. Thesis	2	0+13
M.Sc. Thesis Work	2	

HPC Structure

- **Parallel and Distributed Architectures and Languages**
 - Parallelism and concurrency
 - Types of parallelisms
 - Computing, communication, and coordination models
 - Types of parallel and distributed architectures
 - Programming languages and techniques for parallel and distributed computers
 - Examples of parallel and distributed architectures with specificities of their programming



HPC Structure

- **Parallel and Distributed Algorithms and Data Structures**
 - Mathematical models of systems for parallel and distributed computations
 - Analysis of complexity and correctness of parallel and distributed algorithms
 - Message passing algorithms, shared memory algorithms
 - Data structures for parallel and distributed algorithms
 - Design patterns for parallel programming



HPC Structure

- **High Performance Computer Systems**
 - Concepts, models, and algorithms in HPC
 - Current HPC architectures – from supercomputers to single-board computers
 - Trends in performance and architectures for HPC
 - Accelerators, heterogeneous processors and their programming, GPU computing
 - Numerical algorithms, libraries, and packages
 - Application of HPC in scientific computing, simulation and visualization, and big data analytics



HPC Structure

- **Architectures of Big Data Systems**

- Concepts and methods in data science and big data analytics
- Big data computer systems and algorithms
- Layers in big data systems (batch, serving, and speed)
- Fundamentals of Hadoop
- Components of Hadoop – MapReduce, HDFS, YARN
- Efficient searching in big data sets (Elasticsearch)
- Applications of big data systems in scientific computing and information engineering



HPC Structure

- **Cloud Computing**

- Concepts, methods, and technologies in cloud computing
- Service-oriented architectures, software as a service (SaaS), platform as a service (PaaS), infrastructure as a service (IaaS)
- Virtualization (concepts, methods, and technologies), virtual services and applications
- Data storage and security in the clouds
- Distributed file systems
- Application programming in the cloud
- HPC in the cloud



HPC Structure

- **High Performance Computing in Scientific Computing**
 - Application of HPC with selected mathematical methods and algorithms
 - matrix decomposition, fast Fourier transform, Monte Carlo simulation in solving scientific problems
 - spectral analysis, astrophysics – N-body problem, molecular dynamics, fluid dynamics, etc.
 - Application of specialized programming frameworks and tools for scientific computing
 - Selected case studies



HPC Structure

- **High Performance Computing in Information Engineering**
 - Basic concepts in Information Engineering / Data Science
 - Application of selected methods for data analysis (classification – nearest neighbor, decision trees, support vectors; clusterization – k-means, hierarchical) in HPC systems
 - Application of HPC in processing big data
 - Design patterns in information engineering
 - Hadoop and Elasticsearch in data analysis
 - Selected case studies in business intelligence, prediction of trends, Web data analytics, etc.



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- **Referent M.Sc. Programs**
- **University of Edinburgh**, Edinburgh Parallel Computing Center
 - M.Sc. in HPC, M.Sc. in HPC with Data Science, [link](#)
- **Vrije Universiteit Amsterdam**
 - Master in Parallel and Distributed Comp.Systems, [link](#)
- **International School for Advanced Studies**, Trieste, Italy
 - MHPC – Master in HPC, [link](#)
- **Stanford University**
 - Master of Science, [link](#)



Final Words

- Hopes to initiate the new module in HPC in year 2017
- A complementary module with Information and Analytics Engineering (Data Science) M.Sc. program
 - with hopes to initiate also in year 2017
- Main goal is to meet emergent industry requirements in a high-quality way, in the area of HPC and Data Science



End of Presentation

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