SYLLABUS

Operating Systems for Parallel and Distributed

Architectures

University year 2025-2026

1. Information regarding the programme

1.1. Higher education institution	Babeş Bolyai University
1.2. Faculty	Faculty of Mathematics and Computer Science
1.3. Department	Department of Computer Science
1.4. Field of study	Computer Science
1.5. Study cycle	Master
1.6. Study programme/Qualification	High Performance Computing and Big Data Analytics
1.7. Form of education	Full time

2. Information regarding the discipline

2.1. Name of the discipline	**Operating Systems for Parallel and Distributed Architectures**					Discipline code	**MME8093**
2.2. Course coordinator				Assoc. prof. phd. Darius-Vasile BUFNEA			
2.3. Seminar coordinator				Assoc. prof. phd. Darius-Vasile BUFNEA			
2.4. Year of study	1	2.5. Semester	1	2.6. Type of evaluation	E	2.7. Discipline regime	Mandatory

3. Total estimated time (hours/semester of didactic activities)

3.1. Hours per week	**4**	of which: 3.2 course	2	3.3 seminar/laboratory/project	1/0/1
3.4. Total hours in the curriculum	56	of which: 3.5 course	28	3.6 seminar/laboratory/project	28
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					25
Additional documentation (in libraries, on electronic platforms, field documentation)					25
Preparation for seminars/labs, homework, papers, portfolios and essays					25
Tutorship					12
Evaluations					7
Other activities:					0
3.7. Total individual study hours	**94**				
3.8. Total hours per semester	**150**				
3.9. Number of ECTS credits	**6**				

4. Prerequisites (if necessary)

4.1. curriculum	• Operating Systems • Distributed Operating Systems • Computer Networks
4.2. competencies	• Average administration and programming skills

5. Conditions (if necessary)

5.1. for the course	• Video projector
5.2. for the seminar /lab activities	• Computers, Linux computers and Linux virtual machines for building a cluster, Network infrastructure

6.1. Specific competencies acquired [1]

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

Professional /essential competencies	• Understanding and working with basic concepts of data analysis and modelling • Capability of developing of high-performance programs based on parallel and distributed programming
Transversal competencies	• Team work capabilities; able to fulfil different roles • Etic and fair behaviour, commitment to professional deontology

6.2. Learning outcomes

Knowledge	• The student/graduate knows the key concepts of parallel cluster architectures • The student/graduate knows the basic paradigms of parallel programming • The student/graduate knows the most important formalisms for describing concurrent processes • The student/graduate understands and uses the distributed systems' theory and its basic applications on Grid, Cluster and especially cloud computing environments
Skills	• The student/graduate knows how to build, deploy, configure, maintain, monitor, debug a Linux parallel cluster • The student/graduate knows how to develop parallel algorithms using different models of parallel computation • The student/graduate acquires the main skills and abilities to work with scalable systems that allow solving large problems by dividing them in parallel sub-problems • The student/graduate knows how to handle (extremely) large amounts of digital data in various formats
Responsibility and autonomy:	• The student/graduate knows and follows ethical and deontological norms and rules in scientific research • The student/graduate assumes responsibility for the product of his / her work, requests feedback and uses it constructively • The student/graduate is able to coordinate project management activities, using decision-making skills, critical and innovative thinking, as well as digital skills • The student/graduate manages a workflow and interacts inside a team, makes decisions and manages unforeseen situations

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	• Know the key concepts of parallel cluster architectures
7.2 Specific objective of the discipline	At the end of the course, students will know how to: • build • deploy • configure • maintain • monitor • debug a Linux parallel cluster

8. Content

8.1 Course	Teaching methods	Remarks
1. Introduction to Operating systems for parallel architectures	Exposure, description, explanation, debate and dialogue, discussion of case studies	
2. Parallel Cluster architecture: Cluster Head Nodes, Computer	Exposure, description,	

Nodes, Clustering Middleware	explanation, case studies	
3-4. Parallel Cluster Paradigms: Single system image, Centralized system management, High processing capacity, Resource consolidation, Optimal use of resources, High-availability, Redundancy, Single points of failure, Failover protection and disaster recovery, Horizontal and vertical scalability, Load-balancing, Elasticity, Run jobs anytime, anywhere	Exposure, description, explanation, debate and dialogue, discussion of case studies	
5. Design and configuration. Network prerequisites for a parallel cluster: LAN, bandwidth, latency, interface, security aspects. Nodes automatic configuration and deployment	Exposure, description, explanation, case studies	
6. Virtualization of hardware, operating system, storage devices, computer network resources	Exposure, description, explanation, case studies	
7-8. Beowulf clusters deployment and administrations	Exposure, description, explanation, debate and dialogue, discussion of case studies	
9. Linux Cluster Distributions: Mosix, ClusterKnoppix. Automated operating systems and software provisioning for a Linux Cluster: Open Source Cluster Application Resources (OSCAR), ROCKS	Exposure, description, explanation, case studies	
10. Cluster resources: distributed memory architecture and distributed shared memory, distributed file systems (examples: IBM General Parallel File System, Microsoft's Cluster Shared Volumes, Oracle Cluster File System	Exposure, description, explanation, debate and dialogue, discussion of case studies	
11. Nodes and head node management, Cluster system management, Debugging and monitoring a parallel cluster, Node failure management	Exposure, description, explanation, case studies	
12. Data sharing and communication, Message passing and communication, Parallel processing libraries: Parallel Virtual Machine toolkit and the Message Passing Interface library	Exposure, description, explanation, case studies	
13. Software and development environment, Parallel application development and execution (Parallel Environment – PE), Job scheduling & management	Exposure, description, explanation, case studies	
14. Final review	Exposure, description, explanation, case studies	

Bibliography

1. Gregory Pfister: *In Search of Clusters*, Prentice Hall; 2 edition (December 22, 1997), ISBN-10: 0138997098, ISBN- 13: 978-0138997090
2. George F. Coulouris, Jean Dollimore, Tim Kindberg: *Distributed Systems: Concepts and Design*, Addison-Wesley; 5 edition (May 7, 2011), ISBN-10: 0132143011, ISBN-13: 978-0132143011
3. Joseph D. Sloan: *High Performance Linux Clusters with OSCAR, Rocks, OpenMosix, and MPI*, O'Reilly Media (November 23, 2004), ISBN-10: 0596005709, ISBN-13: 978-0596005702
4. Daniel F. Savarese, Donald J. Becker, John Salmon, Thomas Sterling: *How to Build a Beowulf: A Guide to the Implementation and Application of PC Clusters*, The MIT Press (May 28, 1999), ISBN-10: 026269218X, ISBN-13: 978-0262692182
5. Gordon Bell, Thomas Sterling: *Beowulf Cluster Computing with Linux*, The MIT Press; 1 edition (October 1, 2001), ISBN-10: 0262692740, ISBN-13: 978-0262692748
6. Charles Bookman: *Linux Clustering: Building and Maintaining Linux Clusters*, Sams Publishing; 1 edition (June 29, 2002), ISBN-10: 1578702747, ISBN-13: 978-1578702749

8.2 Seminar / laboratory	Teaching methods	Remarks
1. Project presentation	Conversation, debate, case studies	The Seminar/lab is organized as a total of 7 classes - 2 hours every other week
2. Cluster requirements	Conversation, debate, case studies	
3. Cluster building and deployment	Conversation, debate, case studies	
4. Cluster configuration	Conversation, debate, case studies	
5. Cluster maintenance	Conversation, debate, case studies	

6. Cluster debugging and monitoring	Conversation, debate, case studies	
7. Final evaluation of seminar/lab activities	Conversation, debate, case studies	
Bibliography Students, organized in teams of 4 or 5 members will have to build, deploy, configure, maintain, monitor and debug a Linux parallel cluster. The key concepts to accomplish these goals are presented during the course hours and are also available in the course' bibliography (see above).		

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- Courses with similar content are taught for graduate students in major universities around the world, including: Princeton, Berkeley, MIT.
- Course content is considered very important in the actual context of the increased need of computing power for computational science, interdisciplinary applications, and commercial applications as well, coupled with the high cost and low accessibility of traditional supercomputers.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Percentage of final grade
10.4 Course	Know the key concepts of parallel cluster architectures;	Written exam	30%
10.5 Seminar/laboratory	Know how to deploy, maintain, debug and monitor a parallel cluster	Presentation on a HPC related topic	30%
		Homework assignments	30%
		Default	10%
10.6 Minimum standard of performance			
At least grade 5 (from a scale of 1 to 10) at written exam and seminar/lab activities.			

11. Labels ODD (Sustainable Development Goals)[2]

Not applicable.

Date:
14.04.2025

Signature of course coordinator

Assoc. prof. phd. Darius-Vasile BUFNEA

Signature of seminar coordinator

Assoc. prof. phd. Darius-Vasile BUFNEA

Date of approval:
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Signature of the head of department

Assoc. prof. phd. Adrian STERCA

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable*.".