COURSE SYLLABUS

Academic year 2024-2025

1. Programme Information

1.1. Higher education institution	**Lucian Blaga University of Sibiu**
1.2. Faculty	Faculty of Engineering
1.3. Department	Department of Computer Science and Electrical and Electronics Engineering
1.4. Field of study	Computer Science and Information Technology
1.5. Level of study	Master
1.6. Programme of study/qualification	ADVANCED COMPUTING SYSTEMS

2. Course Information

2.1. Name of course	Research Methods in Advanced Computing Architectures			Code	ACS.101.RO
2.2. Course coordinator	Prof. Arpad GELLERT, PhD				
2.3. Seminar/laboratory coordinator	Camil BĂNCIOIU, PhD				
2.4. Year of study	1	2.5. Semester	1	2.6. Evaluation form	E
2.7. Course type	O	2.8. The formative category of the course			R

3. Estimated Total Time

3.1. Course Extension within the Curriculum – Number of Hours per Week					
3.1.a. Lecture	3.1.b. Seminar	3.1.c. Laboratory	3.1.d. Project	3.1.e. Other	Total
3	-	2	-	0	**5**
3.2. Course Extension within the Curriculum – Total Number of Hours within the Curriculum					
3.2.a. Lecture	3.2.b. Seminar	3.2.c. Laboratory	3.2.d. Project	3.2.e. Other	Total
42	-	28	-	-	**70**

Time Distribution for Individual Study	**Hours**
Learning by using course materials, references and personal notes	28
Additional learning by using library facilities, electronic databases and on-site information	14
Preparing seminars / laboratories, homework, portfolios and essays	70
Tutorial activities	14
Exams	4

3.3. Total Individual Study Hours *($NOSI_{sem}$)*	**130**
3.4. Total Hours in the Curriculum *($NOAD_{sem}$)*	**70**
3.5. Total Hours per Semester *($NOAD_{sem}$ + $NOSI_{sem}$)*	**200**
3.6. No. of Hours / ECTS	**25**
3.7. Number of credits	**8**

4. Prerequisites (if needed)

4.1. Courses that must be successfully completed first (from the curriculum)	-
4.2. Competencies	C/C++/C#/Java Programming skills

5. Conditions (where applicable)

5.1. For course/lectures	Scientific papers, video-projector, blackboard
5.2. For practical activities (lab/sem/pr/app)	Lab room with computers having installed the necessary software

6. Specific competencies acquired

		Number of credits assigned to the discipline	8	Credits distribution by competencies
6.1. Professional competencies	PC22	Model and simulate hardware		2
	PC24	Design hardware systems		1
	PC25	Designs prototypes		1
	PC15	Conducts scientific research		1
	PC23	Present analysis results		1
	PC14	Disseminates results to the scientific community		0,5
6.2. Transversal competencies	TC1	Demonstrates commitment		0,5
	TC3	Takes responsibility		0,5
	TC4	Works in teams		0,5

7. Course objectives (resulted from developed competencies)

7.1. Main course objective	Introduction in Computer Architecture Research
7.2. Specific course objectives	• Understanding the research methods in Advanced Computer Architecture. • Understanding some research papers, technical reports, PhD theses, etc. in the Advanced Computing Architectures domain. • Developing a research project and writing a scientific paper based on it.

8. Content

8.1 Lectures		**Teaching methods**	**Hours**
Lecture 1	Introduction to prediction and speculative execution implemented in Computer Architectures	Exposition, Discussion	3
Lecture 2	Advanced Branch Prediction Methods: Dynamic Neural Branch Prediction, First Neural Dynamic Branch Prediction Models, Perceptron Branch Predictors, Markovian Branch Predictor, Genetic Branch Predictors	Exposition, Discussion	3
Lecture 3	Understanding Some Present-Day Branch Prediction Limits. Unbiased Branches Problem. Finding Unbiased Branches. Research Methodology	Exposition, Discussion	3
Lecture 4	Pre-Computing Branches. The Pre-Computed Branch Algorithm. Complexity and Cost Evaluations. Performance Evaluations through Simulation	Exposition, Discussion	3
Lecture 5	Fetch Bottleneck. Trace-cache processors. Issue (Data- Flow) Bottleneck. Dynamic Instruction Reuse. Function Reuse	Exposition, Discussion	3

Lecture 6	Dynamic Value Prediction and Speculation. Predicting Load Instructions. Generalised Value Prediction. Computational Predictors. Contextual Predictors. Hybrid predictors. The Value Prediction Speedup. A Simple Analytical Model	Exposition, Discussion	3
Lecture 7	Focalizing Dynamic Value Prediction to CPU's Registers. The Register Value Predictor Concept. Register Value Predictors. Register Value Prediction using Meta-predictors	Exposition, Discussion	3
Lecture 8	Neural Network Models with Applications in Ubiquitous Computing. Autonomic Computing. Next Location Prediction. Person Movement Prediction using Neural Networks	Exposition, Discussion	3
Lecture 9	Hidden Markov Models with Applications in Ubiquitous Systems. Next Location Prediction. Discrete Markov Processes. Hidden Markov Models of order 1	Exposition, Discussion	3
Lecture 10	Hidden Markov Models with Applications in Ubiquitous Systems. A possible generalization: Hidden Markov Models of order R>1	Exposition, Discussion	3
Lecture 11	Multiprocessor systems on chips (MPSOCS). Why MPSOCS? Challenges, design methodologies, hardware architectures, software, performance modeling and analysis. Design of communication architectures for MPSOCS.	Exposition, Discussion	3
Lecture 12	Multiprocessor systems on chips (MPSOCS). Memory systems and compiler support for MPSOCS. Component-based design. Models of computation for MPSOCS.	Exposition, Discussion	3
Lecture 13	Multiprocessor systems on chips (MPSOCS). Multicores based on speculative-execution processors. Automatic Design Space Exploration (heuristic algorithms, complex tool implementation).	Exposition, Discussion	3
Lecture 14	Multiprocessor systems on chips (MPSOCS). Network on a Chip simulator and optimal tasks mapping for a parallel software application	Exposition, Discussion	3
		Total lecture hours:	**42**

8.2.b. Laboratory		**Teaching methods**	**Hours**
Laboratory 1	Next Location Prediction in an intelligent UbiCom ambient. A Neural Approach. A Markov Approach. A Hidden Markov Model Approach.	Development, Experiment	2
Laboratory 2	Integrating Dynamic Instruction Reuse (DIR) in an advanced superscalar/SMT microarchitecture. Simulations on SPEC 2000 benchmarks	Development, Experiment	2
Laboratory 3	Integrating Dynamic Value Prediction (DVP) in an advanced superscalar/SMT microarchitecture. Simulations on SPEC 2000 benchmarks	Development, Experiment	2
Laboratory 4	Focalising Dynamic Value Prediction to CPU's Context. Simulations on SPEC 2000 benchmarks	Development, Experiment	2
Laboratory 5	Developing an Adaptive Meta-Predictor for a Hybrid Dynamic Value Predictor (multiple DVPs). Simulations on SPEC 2000	Development, Experiment	2
Laboratory 6	Integrating Advanced Hybrid Branch Predictors (Two Level Adaptive + Neural, Perceptron) in an advanced superscalar microarchitecture. Simulations on SPEC 2000 and INTEL CBP	Development, Experiment	2
Laboratory 7	Understanding and Predicting Indirect Branch Behavior. Simulations on SPEC 2000 benchmarks and some developed specific C/C++ programs	Development, Experiment	2
Laboratory 8	Detecting and Predicting Unbiased Branches. Simulations on SPEC 2000 and INTEL CBP benchmarks	Development, Experiment	2
Laboratory 9	Solving Fetch Bottleneck. Trace-Processor Simulation (SPEC 2000)	Development, Experiment	2
Laboratory 10	Investigating Procedural/Object Programming Corpus' Influence on DIR/DVP	Development, Experiment	2

Laboratory 11	Simulating Multicore Architectures. Full system simulation (SNIPER)	Development, Experiment	2
Laboratory 12	Automatic Design Space Exploration in Multicore Systems. Multi-objective Optimization Methods (PARETO)	Development, Experiment	2
Laboratory 13	Network on a Chip simulator and optimal tasks mapping for a parallel software application	Development, Experiment	2
Laboratory 14	Parallel Programming. Optimal mapping on heterogeneous multicore systems (accelerating some Computational Fluid Dynamics Programs)	Development, Experiment	2
		Total laboratory hours:	28

9. Bibliography

9.1. Recommended Bibliography	Lucian Vintan, *Prediction Techniques in Advanced Computing Architectures*, Matrix Rom Publishing House, Bucharest, ISBN 978-973-755-137-5, 2007 (292 pg.); LBUS Library: 52.103
	Arpad Gellert, Lucian Vintan, Adrian Florea, *A Systematic Approach to Predict Unbiased Branches*, "Lucian Blaga" University Press, ISBN 978-973-739-516-0, Sibiu, 2007 (111 pg.); LBUS Library: 53.048
	Arpad Gellert, *Beyond the Limits of Modern Processors*, Matrix Rom Publishing House, ISBN 978-973-755-426-0, Bucharest, 2008; LBUS Library: 04/G29
9.2. Additional Bibliography	John Hennessy, David Patterson, *Computer Architecture: A Quantitative Approach*, Morgan Kaufmann, Fifth Edition, ISBN 978-0-12-383872-8, 2011

10. Conjunction of the discipline's content with the expectations of the epistemic community, professional associations and significant employers of the specific study program

Curricula are continuously updated based on the most prestigious international text-books and also based on the most relevant progresses in this field (research projects and scientific papers).

11. Evaluation

Activity Type	11.1 Evaluation Criteria	11.2 Evaluation Methods		11.3 Percentage in the Final Grade	Obs.
11.4a Exam / Colloquy	Theoretical knowledge acquired	Preparing a research topic	20%	40%	CPE
		Final evaluation	20%		
11.4c Laboratory	Practical knowledge acquired	Experimental works		60%	CPE
11.5 Minimum performance standard					50%

The Course Syllabus will encompass components adapted to persons with special educational needs (SEN – people with disabilities and people with high potential), depending on their type and degree, at the level of all curricular elements (skills, objectives, contents, teaching methods, alternative assessment), in order to ensure fair opportunities in the academic training of all students, paying close attention to individual learning needs.

Filling Date: 10.09.2024

Department Acceptance Date: 16.09.2024

	Academic Rank, Title, First Name, Last Name	Signature
Course Teacher	Prof. Arpad GELLERT, PhD	
Study Program Coordinator	Prof. Adrian FLOREA, PhD	

Head of Department	Assoc. Prof. Radu George CREȚULESCU, PhD	
Dean	Prof. Maria VINȚAN, PhD	

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