International Information Technology University JSC

Faculty of Information Technology

Department of Mathematical and Computer Modeling

Approved
Vice-Rector for Academic and
Educational Affairs of IITU JSC, PhD
_____ Umarov T.F.
«___» _____ 2019

SYLLABUS
(ACADEMIC PROGRAM)

Course: ASPV 3302 Architecture of Parallel Computing Systems

Major: 5B060200 Computer Science

Year: 3; **Semester:** 6; **Number of credits**: 3 ECTS

Lectures: 15 hours

Practical classes: 15 hours

T/SIS: 60 hours

Total: 90 hours

Final assessment form: Examination

Almaty 2019

Academic program of the course ASPV 3302 Architecture of Parallel Computing Systems has been reviewed at the meeting of Mathematical and Computer Modeling department.

Minutes №1 dated «27» August 2019.

Head of department _____ Rysbaiuly B.,
signature
Doctor of Physical and
Mathematical Sciences, Professor

Author _____ Alpar S.D.,
signature
Lecturer, Master

The working academic program was approved at the meeting of the Educational and Methodological Board of JSC "IITU"

Minutes №1 dated «29» August 2019.

Director of the Department
for Academic Affairs _____ A.K.Mustafina
signature

1. GENERAL INFORMATION	
Faculty	Information Technology
Major code and title	5B060200 Computer Science
Year, semester	3rd year, 6th semester
Subject category	Profiling
Number of credits (ECTS)	3
Prerequisites	Programming languages
Postrequisites	CUDA system parallel computation
Lecturer, instructor	Alpar S.D., lecturer, Master of Engineering Sciences Office #807, e-mail: rapla.natlus@gmail.com Office hours: Tue, Wed, Fri 11.00-13.00

2. GOALS, OBJECTIVES AND LEARNING OUTCOMES OF THE COURSE

The course goal is learning the basics of parallel algorithms, programming with help of OpenMP and MPI technologies to solve practical problems using the C++ language.

The objectives of the course are to give an overview of the architectures and communication networks employed in parallel computers. The course covers the foundations for development of efficient parallel algorithms, including examples from relatively simple numerical problems, sorting, and graph problems. Adaption of algorithms to special computer architectures is discussed.

Learning outcomes of the course

Students successfully completing the course will be able to:

- Analyze the requirements for programming parallel systems and critically evaluate the strengths and weaknesses of parallel programming models and how they can be used to facilitate the programming of concurrent systems.
- Discuss the difference between the major classes of parallel processing systems and design software solutions for a number of parallel processing models.
- Design and implement a SIMD and MIMD parallel processing solution.
- Analyze the efficiency of a parallel processing system and evaluate the types of application for which parallel programming is useful.

3. COURSE DESCRIPTION

This course “Parallel computation” covers topics such as design methodologies for parallel programming systems, performance of parallel processing systems, and the application of parallel programming for building active-process based, graphical interfaces. Emphasis will be given to practical case studies of parallel programming scenarios and solutions.

4. COURSE POLICY

Students are forbidden to:

- submit any tasks after the deadline. Late submissions are graded down.
- cheat. Plagiarized papers shall not be graded;
- be late for classes;
- retake any tests, unless there is a valid reason for missing them;
- use mobile phones in class.

Students should always

- be appropriately dressed (formal/semi- formal styles are acceptable);
- show consideration for and mutual support of teachers and other students;

let the teacher know of any problems arising in connection with their studies.

5. LITERATURE

Basic literature:

1. Parallel Programming: Concepts and Practice 1st Edition, 2017
2. Pavan Balaji, Programming Models for Parallel Computing, MIT Press, 2015

3. Ruud van der Pas, Using OpenMP—The Next Step: Affinity, Accelerators, Tasking, and SIMD (Scientific and Engineering Computation), 1st edition, the MIT Press, 2017

Supplementary literature:

1. http://mpi.deino.net
2. https://www.openmp.org

6. COURSE SCHEDULE

Abbreviations

Abbreviation	Meaning
TSIS	Teacher supervised independent work (TSIS)
SIS	Students' independent work (SIS)
PA	Practical assignment
LW	Laboratory Work
Abbreviation	Meaning

Week No	Course Topic	References	Lectures (1 h/w)	Prac. sessions (1 h/w)	TSIS (1 h/w)	SIS (each 7,5 h)
1	**Introduction to OpenMP. Basic concepts.** Compilation of the program. Parallel Program Model	[1]-[3]	L 1	PA 1	TSIS 1	
2	**Directives and functions.** Omp pragma parallel directive.	[1]-[3]	L 2	PA 2	TSIS 2	SIS1
3	**Single directive. Master directive.** Implementation.	[1]-[3]	L 3	PA 3	TSIS 3	
4	**Parallel tasks.** Parallel loops. #pragma omp parallel for directive.	[1]-[3]	L 4	PA 4	TSIS 4	SIS2
5	**Parallel sections. Synchronization.** Barrier. Explicit and implicit barrier.	[1]-[3]	L 5	PA 5	TSIS 5	
6	**Directive ordered.** Critical sections.	[1]-[3]	L 6	PA 6	TSIS 6	SIS3
7	**Atomic directive. Flush directive.** Use of OpenMP for numerical problems.	[1]-[3]	L 7	PA 7	TSIS 7	
8	**Introduction to MPI. Basic concepts.** Compilation of the program with use of MPI.	[1]-[3]	L 8	PA 8/ Midterm	TSIS 8	
9	**MPI routines and functions.** MPI_Init(); MPI_Comm_rank(); MPI_Comm_size();	[1]-[3]	L 9	PA 9	TSIS 9	SIS4
10	**Sending and Receiving of messages.** MPI_Send(); MPI_Recv();	[1]-[3]	L 10	PA 10	TSIS 10	
11	**Gathering values from processes.** MPI_Gather(); MPI_Allgather();	[1]-[3]	L 11	PA 11	TSIS 11	SIS5
12	**Sending data from one(all) to all processes.** MPI_Scatter(); MPI_Reduce(); MPI_Allreduce();	[1]-[3]	L 12	PA 12	TSIS 12	

13	**Topology. Communicators. Cartesian topology.** MPI_Cart_create(); MPI_Cart_coords();	[1]-[3]	L 13	PA 13	TSIS 13	SIS6
14	**Using MPI for Heat equation.** Decomposition.	[1]-[3]	L 14	PA 14	TSIS 14	
15	**Using hybrid parallelization by combining MPI and OpenMP.**	[1]-[3]	L 15	PA 15/ End of term	TSIS 15	
	Total hours	**90**	**15**	**15**	**15**	**45**

7. The list of topics / tasks for practical lessons

№	Assignments (topics)	Hours	References	Form of submission	Deadline
1	Parallel Program Model	1	[1]-[3] S[1]-[2]	Submission to DL	01.02.2020
2	Omp pragma parallel directive.	1	[1]-[3] S[1]-[2]	Submission to DL	08.02.2020
3	Implementation of single directive. Master directive.	1	[1]-[3] S[1]-[2]	Submission to DL	15.02.2020
4	Parallel loops. #pragma omp parallel for directive.	1	[1]-[3] S[1]-[2]	Submission to DL	22.02.2020
5	Barrier. Explicit and implicit barrier.	1	[1]-[3] S[1]-[2]	Submission to DL	29.02.2020
6	Directive ordered. Critical sections.	1	[1]-[3] S[1]-[2]	Submission to DL	07.03.2020
7	Use of OpenMP for numerical problems.	1	[1]-[3] S[1]-[2]	Submission to DL	14.03.2020
8	Compilation of the program with use of MPI.	1	[1]-[3] S[1]-[2]	Submission to DL	20.03.2020
9	MPI routines and functions.	1	[1]-[3] S[1]-[2]	Submission to DL	28.03.2020
10	Sending and Receiving of messages	1	[1]-[3] S[1]-[2]	Submission to DL	04.04.2020
11	Gathering values from processes	1	[1]-[3] S[1]-[2]	Submission to DL	11.04.2020
12	Sending data from one(all) to all processes	1	[1]-[3] S[1]-[2]	Submission to DL	18.04.2020
13	Topology. Communicators. Cartesian topology.	1	[1]-[3] S[1]-[2]	Submission to DL	25.04.2020
14	Using MPI for Heat equation.	1	[1]-[3] S[1]-[2]	Submission to DL	02.05.2020
15	Using hybrid parallelization by combining MPI and OpenMP.	1	[1]-[3] S[1]-[2]	Submission to DL	08.05.2020

8. List of assignments for Student Independent Study

№	Assignments (topics) for Independent study	Hours	References	Form of submission	Deadline
1	Using OpenMP technologies for calculation of Matrix multiplication.	7.5	[1]-[3] S[1]-[2]	Defense of IHW	3rd week
2	Parallelization of Simpson method.	7.5	[1]-[3] S[1]-[2]	Defense of IHW	5th week
3	Using OpenMP tools for numerical solution of Heat equation 2D.	7.5	[1]-[3] S[1]-[2]	Defense of IHW	7th week
4	Using MPI technologies for calculation of Matrix multiplication. Performance.	7.5	[1]-[3] S[1]-[2]	Defense of IHW	10th week
5	Parallelization of Rectangle method with use of MPI.	7.5	[1]-[3] S[1]-[2]	Defense of IHW	12th week
6	Using MPI tools for numerical solution of Heat equation 2D. Decomposotion.	7.5	[1]-[3] S[1]-[2]	Defense of IHW	14th week

9. System for evaluating student performance in a discipline:

Each type of educational work is evaluated on a 100-point scale and is included in the average assessment of current control, taking into account the weight coefficient in accordance with the table:

Period	Assignments	Number of points	Coefficient	Total
1st attestation	Individual Home Work # 1 Individual Home Work # 2 Individual Home Work # 3 Midterm	100 100 100 100	0.2 0.2 0.2 0.4	**100**
2nd attestation	Individual Home Work # 4 Individual Home Work # 5 Individual Home Work # 6 End of term	100 100 100 100	0.2 0.2 0.2 0.4	**100**
Final exam				**100**
Total	**0,3*1stAtt+0,3*2ndAtt+0,4*Final**			**100**

*If the number of absences exceeds 20%, student will be automatically scheduled for a Retake (summer semester)

10. Assessment criteria:

The point-rating letter system for assessing the educational achievements of students with their translation into the traditional grading scale:

Letter Grade	Numerical equivalent	Points (% based)	Grading scheme	General description of evaluation
A	4,0	95-100	«Excellent»	The student owns the knowledge of the subject in full, deeply comprehends the discipline; shows a high level of knowledge in excess of the amount provided by the syllabus, gives a comprehensive answer
A-	3,67	90-94		The student owns the knowledge of the subject in full, deeply comprehends the discipline; gives a comprehensive answer
B+	3,33	85-89	«Good»	The student shows complete, sufficiently substantiated knowledge of the subject, but the answers did not always highlight the main thing, rational calculation methods were not always used; answers were mostly concise and not always clear.
B	3,0	80-84		
B-	2,67	75-79		
C+	2,33	70-74		
C	2,0	65-69	«Satisfactory»	The student demonstrates sufficient knowledge of the subject, but without the proper depth and justification, the answers are fuzzy and without the proper logical sequence;
C-	1,67	60-64		
D+	1,33	55-59		
D	1,0	50-54		
FX	0,5	25-49	«Fail» with re-exam	The student demonstrates insufficient knowledge of the subject; to certain answers not given positive answers.
F	0	0-24	«Fail»	The student demonstrates a very low level of knowledge of the subject.