Siberian Federal University

Supercomputer technologies for solving problems of research activities

Course Guide

This course contributes to the requirements for the Degree of Candidate of Science in Computer Science.

Krasnoyarsk, 2020.

Table of Contents

1. Course Description

This course contributes to the requirements for the Degree of Candidate of Science in Computer Science.

Title of the Academic Program	Programs in English "Information and computer Science"
Type of the course	core /mandatory
Course period	1 semester (12 weeks) From February, the 16 to June, the 7 (12 weeks)
Study credits	2 ECTS credits
Duration	72 hours
Language of instruction	English
Academic requirements	– Master's Degree in Computer Science or equivalent (transcript of records), – good command of English (certificate or other official document) **Prerequisites:** – **Advanced knowledge** of math**,** digital electronics, programming skills.

1.1 Course overview

The course "Supercomputer technologies for solving problems of research activities" is designed to help graduate students master modern supercomputing technologies to perform scientific calculations in their respective professional fields. Students will receive an extensive overview of supercomputing technologies. During their studies, they also will learn how to work with high-performance cluster systems running under the Linux operating system.

The course will use IBM supercomputer complex.

1.2 Special features

The course provides an opportunity to graduate students to work with supercomputer closely on the own scientific tasks.

1.3 Course aims and objectives

Course Aims

- ***The aim*** of the course is graduate students teaching a modern technology of high-performance computing that will perform him scientific calculations in their professional fields

Course Objectives

- to familiarize graduate students with specifics of parallel computing;
- to acquaint graduate students with the current trends in supercomputing technologies;
- to teach graduate students to perform scientific calculations on supercomputer complexes.

1.4 Learning outcomes

By the end of the course, graduate students will know:

- current trends in supercomputing technologies;
- principles of organization of supercomputer complexes;
- modern parallelization tools.

By the end of the course, students will be able to:

- ability to apply modern supercomputer technologies to accelerate scientific and technical calculations;
- use the acquired knowledge to select tools for effective solution of scientific and practical problems on supercomputer complexes.

By the end of the course, students will possess:

- the necessary skills for carry out of scientific calculations onto supercomputer complexes.

2. Course Lecturer, Contact Information

Dr. Dmitry A. Kuzmin,
PhD in Technical Sciences, Associate professor,
Head of HPC Department,
Krasnoyarsk State Technical University, Faculty of Informatics and Computer Science
(room ULK 4-06) 26, Kirenskogo st, Krasnoyarsk, Russia
e-mail: dkuzmin@sfu-kras.ru
Google Scholar:
Profile on another site(s):
ORCID:
Web of Science ResearcherID: AAF-8808-2019
Additional information is available at:
http://structure.sfu-kras.ru/node/1270

3. Prerequisites

A background in OS Linux and programming will help in faster and better understanding of every topic. Nevertheless, each part of the course includes a short introduction of methods that are required for its study. Therefore, a graduate student without the denoted experience must be encouraged to make some additional efforts in education.

4. Course Outline

Week	Lectures	Seminars/ Assignments	Hours Lec/Lab/HA
Semester 1			
1-12	Recommendations for the course. Literature review. Overview of the current state of supercomputing technologies. Hybrid high-performance systems based on GPU and FPGA. High-performance Computing on high-performance cluster systems. Programming technologies for heterogeneous computing systems. GPU applications for high-performance computing. High-level mathematical libraries in parallel computing	Carry out of scientific calculations onto supercomputer complexes.	12/12/48
	12	60	72
12	Final Exam		

4.1 Course requirements

4.1.1 Web-page of the course

Course materials and required reading materials are available on the webpage of the , SibFU E-learning portal, . You must be logged in to access this course. https://e.sfu-kras.ru/course/view.php?id=27851

4.1.2 Required reading

The main book for this course is The ***Course Book***. It provides students with all the information they need to master methods and tools for research in science field.

1. The Student Supercomputer Challenge Guide: From Supercomputing Competition to the Next HPC Generation 1st ed. 2018 Edition by ASC Community (Author) ISBN-13: 978-9811037306 https://www.researchgate.net/publication/324011061_The_Student_Supercomputer_Challenge_Guide
2. Introduction to Parallel Computing From Algorithms to Programming on State-of-the-Art Platforms Authors: Trobec, R., Slivnik, B., Bulić, P., Robič, B. 2018 ISBN 978-3-319-98833-7

3. Thinking in Parallel: Some Basic Data-Parallel Algorithms and Techniques (104 pages) by Uzi Vishkin – October 12, 2010
4. Open Textbook: Programming on Parallel Machines; GPU, Multicore, Clusters and More Professor Norm Matloff , University of California, Davis
5. Introduction to High Performance Computing for Scientists and Engineers (Chapman & Hall/CRC Computational Science) 1st Edition by Georg Hager (Author), Gerhard Wellein (Author) ISBN-13: 978-1439811924
6. Accelerated Computing - Training/Nvidia Developer

4.1.3 Course materials

The main materials that will guide a student through the course are available on the webpage of the , SibFU E-learning portal, . It contains all of topics of this course according to the schedule. It will provide you with useful links that help graduate students to improve their understanding of the topics.

4.1.4 Required feedbacks

Graduate students are free to contact the lecturer by email. The name of department and a number of a group should be written in the subject or in the beginning of the letter for convenience. More information on how to contact the lecturer can be found in «Lecturer information» section of this Guide.

Student's Home or Seminars reports must be attached as a separate pdf file. Student's name and group number should be written on the first page of the file. Students send this report in electronic form only before the deadline.

If necessary, the lecturer will schedule a video-conference, upon request.

4.2 Course Structure

Learning Activities	**Hours**
Lectures	12
Practice sessions / Seminars,	12
Self-study Assignments	48
Final Exam (including preparation)	
Total study hours	**72**

4.3 Time schedule of the course and course outline

№	Theme	Week	Learning Activities	Hours	Home Assignment and Reading
Semester 1					
1	Supercomputing technologies	1-12	**Lecture 1** Recommendations for the course. Literature review.	2	Look on the topic in the e-course
			Lecture 2 «Overview of the current state of supercomputing technologies»	4	E-course topic «Overview of the current state of supercomputing technologies» Answer the test questions on the topic in the e-course.
			Seminar 1 «Basics of working with a supercomputer complex»	4	E-course topic Seminar 1 «Basics of working with a supercomputer complex»
			Home assignment 1	16	Read the books: The Student Supercomputer Challenge Guide: From Supercomputing Competition to the Next HPC Generation 1st ed. 2018 Edition by ASC Community (Author) ISBN-13: 978-9811037306 Issue a report about Seminar 1.
			Lecture 3 «Computing on high-performance cluster systems».	4	E-course topic «Computing on high-performance cluster systems» Answer the test questions on the topic in the e-course.
			Lecture 4 «GPU applications for high-performance computing»	2	E-course topic «GPU applications for high-performance computing» Answer the test questions on the topic in the e-course.
			Seminar 2 «Making parallel applications for	6	E-course topic Seminar 2 «Making parallel applications for cluster systems»

№	Theme	Week	Learning Activities	Hours	Home Assignment and Reading
			cluster systems»		
			Home assignment *2*	16	Read the books: 1.Introduction to Parallel Computing From Algorithms to Programming on State-of-the-Art Platforms Authors: Trobec, R., Slivnik, B., Bulić, P., Robič, B. 2018 ISBN 978-3-319-98833-7 2. Open Textbook: Programming on Parallel Machines; GPU, Multicore, Clusters and More Professor Norm Matloff , University of California, Davis http://heather.cs.ucdavis.edu/parprocbook Issue a report about Seminar 2.
			Seminar 3 Calculating your projects on high-performance systems	2	Listen to the presentation of your projects
			Home assignment *3*	16	Read the book: Introduction to High Performance Computing for Scientists and Engineers (Chapman & Hall/CRC Computational Science) 1st Edition by Georg Hager (Author), Gerhard Wellein (Author) ISBN-13: 978-1439811924 Issue a presentation of your project
5	Final exam				Prepare to final exam. Preparation for answering exam questions (available at e-courses and course book). Preparation for solving control problems using the course book, main books and the e-course.

5. Assessment

Assessment strategy	Points, max	Evaluation criteria
Tests	20	Test questions for lectures in the e-course
Seminars	40	Seminars report
Individual Project	40	Presentation of project
Final exam	10	Two questions about the course material studied

Grading policy for final assessment is:

- A (excellent work) 91–100 points
- B (above average) 81–90 points
- C (average) 71–80 points
- D (below average) 50–70 points
- F (failed) < 50 points

The final exam is oral and written test. Students should be able to answer two short theoretical questions.

6. Attendance Policy

Students are expected to attend classes regularly. In case of missing an in-lab activity a student should perform additional work submitted to the instructor within a week after a class was missed.

Every topic involves an assignment. A written report on the assignment should be submitted within two weeks from the moment students received a list of problems. The final mark will rely on the same grading policy as for the final exam.

7. Required Course Participation

There are no special requirements for the course participation. The preferred type of report submission is the electronic one. Students can use the web-version of the course (link) for a better progress. All problems for solution could be found there together with text from the course book.

8. Facilities, Equipment and Software

Software:

- Linux operating system
- NVidia CUDA Toolkit
- MPI (MPICH), OpenMP

All software is free, no license required

Laboratory equipment:

IBM supercomputer cluster system

Annex 1 Example of Pre-Course Test Questions

1. The concept of a process in Linux.
2. The concept of thread.
3. Classification of computer systems.
4. Main features of the Linux system

Annex 2 Outlines of Seminar works

(List one. The title)

"SIBERIAN FEDERAL UNIVERSITY"
Institute of Space and Information Technologies
Department of Computer Science
Master's Degree Programs “Digital intelligent control systems”
Group No *(Group identifier)*

REPORT ON SEMINAR WORK No. *(Number of seminar)*
Theme: *(Theme of task).*

Tutor: *(Tutor’s / Lecture’s Name and Surname).*

Student: *(Student`s Name and Surname).*

Krasnoyarsk, 20__

(List two, etc. The progress)

Main aim: (Describe the aim of seminar).
The task: (Describe the task of seminar).
Solution: (short description (no more than 2-3 pages) of the problem solving process).

Annex A Diagram(s)

(device connection diagrams and graphs).

Annex B Code(s)

(source code Included comment).

Annex 3 Example of Final Oral Exam Questions

1. Types of high-performance systems
2. Implementation of multitasking in modern operating systems.

1. Concepts of workload, performance, and acceleration.
2. Features of parallel algorithms based on message transmission.