PARALLEL COMPUTING

Tasks and objectives

The training course is intended for mastering knowledge and skills necessary for successful start of professional activity in the domain of parallel programming.

A distinctive feature of the training course is its integrity. The course provides necessary theoretical knowledge in the domain of parallel calculations and practical skills in development of parallel programs.

The training course can be used as an introduction to parallel programming in training of to be physics and mathematics (bachelor's degree, specialist's degree, master's degree) for education programs of basic and supplementary education (including development and retraining programs).

Student Requirements

Knowledge of K101 "Introduction to Programming Methods 1", K102 "Introduction to Programming Methods 2", K210 "Algorithms and Data Structures", M207 "Discrete Mathematics", K206 "Architecture of Computing Systems", K202 "Operating Systems". For performance of practical and laboratory tasks knowledge of C programming methods is required

Course description

The main sections of the course are as follows:

- **Tasks and Objectives of Parallel Data Processing Implementation – 2 academic hours**

  Importance of a perspective of parallel calculations.

- **Parallel Computing Systems Building Principles – 4 academic hours**

  Review of modern parallel computing systems. Classification and productivity assessment. Concept of cluster systems.

- **Models of Calculations and Methods of Efficiency Analysis – 4 academic hours**

  Parallel calculations performance indicators: acceleration, efficiency, scalability. A model of calculations in the form of an operations-operands graph. Model analysis: parallel method execution time measuring, assessment of maximum achievable parallelization, selection of computation load distribution variant. Computing model aggregation.

- **Analysis of Parallel Algorithm Communication Labor-Intensity – 4 academic hours**

  Network topology criteria assessment. Routing algorithms data transmission methods. Standard interaction operations. Methods of network topology logical presentation. Assessment of data transmission time for cluster systems.

- **Parallel Programs Development Technology for Multiprocessor Distributed Memory Systems (MPI messages transmission standard) – 6 academic hours**

  General description of the MPI standard. Data transmission modes. Collective operations. Design of derived data types. Control of processes. Creating logical topologies. Examples: matrix calculations, partial differential equations solving.

- **Models of Parallel Programs Functioning – 6 academic hours**

  Presentation of a parallel program as a system of processes carried-out in parallel. Provision of mutual exclusion, when using shared resources. Semaphore and monitor concepts.

Modeling of a program status in the form of a process-resource graph. Model analysis: detection and elimination of deadlock situations. Use of Petri networks. Standard mutual exclusion tasks: producer-consumer problem, dining philosophers problem, etc.

- **Parallel numerical algorithms for solution of standard calculus mathematics problems – 4 academic hours**

  Matrix calculations (matrix multiplication, transposition, solution of linear equations systems). Sorting. Graph processing. Optimization.

- **Parallel Programs Development Technology for Multiprocessor Shared Memory Systems (OpenMP standard) – 2 academic hours**

  General characteristic of OpenMP standard. Creation of parallel areas. Distribution of computing load between threads. Work with data. Synchronization. Environment functions and variables. Comparison of parallel programming approaches for systems with distributed and shared memory.

  The training course includes expanded laboratory training in parallel programming. This practical training contains process laboratory works for mastering MPI and OpenMP technologies, and tasks for development of parallel programs for complex computation and labor-intensive problem solving.

Course materials:

- electronic training materials;
- presentations for lectures (including a complete set of video lectures);
- set of laboratory works;
- Parallel Laboratory training system (Paralab) for studying of parallel algorithms;
- library of parallel methods for solution of calculus mathematics problems.

Expected results of training

Trainees who successfully completed the training course will acquire the following knowledge and skills:

- parallel algorithms implementation for solution of standard problems of computational mathematics (matrix calculations, sorting, graph processing, optimization),
- analysis and decomposition of calculations into parts, that allow concurrent processing,
- use of OpenMP and MPI technologies for development of parallel programs for computing systems with shared and distributed memory,
- simulation experiments on high-performance computing systems
- performed parallel calculations efficiency assessment.

References

1. Gergel V. Theory and Practice of Parallel Calculations, Internet University of Information Technologies, Binomial, 2007
2. Gergel V. High-performance Calculations for Multiprocessor Multicore Systems, Moscow University Publishing House, 2010

3. Kornyakov K. Kustikova V., Meerov I. Sidnev A. Sysoyev A. Shishkov A. Parallel Programming Tools in Shared Memory Systems, edited by Gergel V. Moscow University Publishing House, 2010

Additional Information

The training course can be readily distributed. The materials of the course are shown in full on the site of the mathematical support chair of the Nizhny Novgorod State University – see http://www.software.unn.ac.ru/ccam/?doc=14

The course is a part of the training materials library of the Microsoft Russian site – see http://www.microsoft.com/Rus/Msdnaa/Curricula. The English version can be found at https://www.academicresourcecenter.net/curriculum/pfv.aspx?ID=6594.

A trainee can pass the examination remotely on the website of the Internet University of Information Technologies (http://www.intuit.ru/department/calculate/paralltp) and through the system of remote learning of the Nizhny Novgorod State University (http://e-learning.unn.ru).

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Website of the Training Course: http://www.hpcc.unn.ru/?doc=98

Contacts

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