COM 451, Parallel and Distributed Programming

American University of Central Asia
Software Engineering Program

1 Course Information

Course ID
COM 451, 3708

Course Repository
`https://github.com/auca/com.451`

Class Discussions
`https://piazza.com/class/j6tftykciix26`

Place
AUCA, laboratory G31

Time
Monday 14:10–15:25
Monday 14:10–15:25

2 Prerequisites

- COM-324, Algorithm Analysis
- COM-341, Operating systems

3 Contact Information

Instructor
Toksaitov Dmitrii Alexandrovich
toksaitov_d@auca.kg

Office
AUCA, room 315

Office Hours
Monday 15:25–17:00
Tuesday 15:25–17:00
Wednesday 10:00–17:00
Thursday 15:25–17:00
Friday 15:25–17:00

4 Course Overview

The course introduces students to the topic of programming multi-core multi-processor systems with data-parallel facilities of various hardware on a single machine or in a distributed system connected to a high-performance network. The students will learn the most popular shared-memory parallel programming API such as Pthreads and a distributed memory programming API such as MPICH. Students will get a chance to work on two projects accelerating image processing tasks and astronomy simulations. Results of the projects will be tested together with students on high-performance parallel machines on the Amazon's cloud.

5 Topics Covered

- Flynn's taxonomy
- Amdahls law
- CPU caches and locality
- CPU pipelines and branch prediction
- Hardware multithreading
- Shared and distributed memory systems
- NUMA and UMA architectures
- Data-parallelism with SIMD instructions
- General-purpose computing on graphics processing units
- Synchronization
  - Spinlocks, barriers, mutexes, semaphores
  - Conditional variables
  - Race conditions
  - Deadlocks

6 Examinations

Students will get midterm and final examinations in the form of two quizzes with multiple choice or open questions. Exam samples can be found on the official course repository.

7 Course Projects

Throughout the course, students will work on two major projects to accelerate programs performing image processing tasks and astronomy simulations.

7.1 Project #1

In the first projects, students will be asked to accelerate a Sobel and Median filters in an image-processing program by utilizing all the cores of a test machine through the Pthread API. They may also accelerate their solutions even further by utilizing the parallel vector-processing facilities such as SIMD instructions of modern CPUs. For extra points, students may move the image processing algorithms to the GPU and compare the achieved speed up.

7.2 Project #2

The second project requires accelerating the N-body simulation in a distributed environment with a high-speed interconnection between machines through the Message Passing Interface. Students will compete on how many planetary bodies can their accelerated systems handle compared to others.

8 Reading

An Introduction to Parallel Programming by Peter Pacheco (ISBN: 978-0123742605)

8.1 Supplemental Reading

1. Parallel Programming, 2nd Edition by Thomas Rauber and Gudula Rnger (ISBN: 978-3642048173)
2. Computer Architecture: A Quantitative Approach, 5th Edition by David Patterson and John L. Hennessy (ISBN: 978-0123838728)

9 Grading

- Class participation (through Piazza) (5%)
- Midterm (15%)
- Final (20%)
- Course projects (60%)

– 90%–100%: A
– 80%–89%: A-
– 70%–79%: B+
– 65%–69%: B
– 60%–64%: B-
– 56%–59%: C+

- 53%–55%: C
- 50%–52%: C-
- 46%–49%: D+
- 43%–45%: D
- 40%–42%: D-
- Less than 39%: F

10 Rules

Students are required to follow the rules of conduct of the Software Engineering Department and American University of Central Asia.

Team work is NOT encouraged. The same blocks of code or similar structural pieces in separate works will be considered as academic dishonesty and all parties will get zero for the task.