

TDDD56

Multicore and GPU Programming

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Staff 2023

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 - Lectures on GPU programming, GPU labs
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 - Director of undergraduate studies

Course Moments

- Lectures
- Lessons
 - Lab introduction lessons, mandatory for the labs
 - Exam training lessons at the end of the course
- Labs (mandatory presence)

- Credits:
 - Written exam, 3 hp
 - Lab series attended and completed by deadlines, 3 hp
 - ▶ No guarantee for completing / correcting labs after the deadlines

Lectures (1)

- **Lecture 1:** Organization, Overview.
Motivation, Multicore architectural concepts and trends (CK)
- **Lecture 2:** Shared memory architecture concepts* (CK)
- **Lecture 3a:** Parallel programming with threads (CK)
- **Lecture 4:** Non-blocking synchronization (CK)
- **Lecture 3b:** Parallel programming with tasks (CK, 45min)
Lesson 1: CPU lab 1+2 introduction (SQ, 45min)
- **Lectures 5-6:** Design and analysis of parallel algorithms* (CK)
- **Lecture 7:** Parallel sorting algorithms (CK)
- **Lecture 8:** Parallel algorithmic design patterns and skeletons.
(CK, 45min)
Lesson 2: Introduction to skeleton programming in SkePU /
Lab 3 (SQ, 45min)

Lectures (2)

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- **Lecture 9:** GPU architecture and trends (IR)
- **Lecture 10:** Introduction to CUDA programming. (IR)
- **Lecture 11:** CUDA programming. GPU lab introduction. (IR)
- **Lecture 12:** Sorting on GPU. Advanced CUDA issues. (IR)
- **Lecture 13:** Introduction to OpenCL. (IR)
- **Lesson 3:** OpenCL. Shader programming. Exercises. (IR)
- **Lesson 4:** Selected theory exercises, exam training. (CK)
- **Lecture 14:** Optimization and parallelization of loop-based sequential programs* (CK)

Lab Series (1)

CPU-labs (week 45, 46, 47)

- Lab 1: Load balancing (warm-up)
- Lab 2: Nonblocking synchronization
- Lab 3: Skeleton programming; Median filtering

GPU-labs (week 48, 49, 50)

- Lab 4: CUDA 1
- Lab 5: CUDA 2
- Lab 6: OpenCL and Shader programming

Lab Series (2)

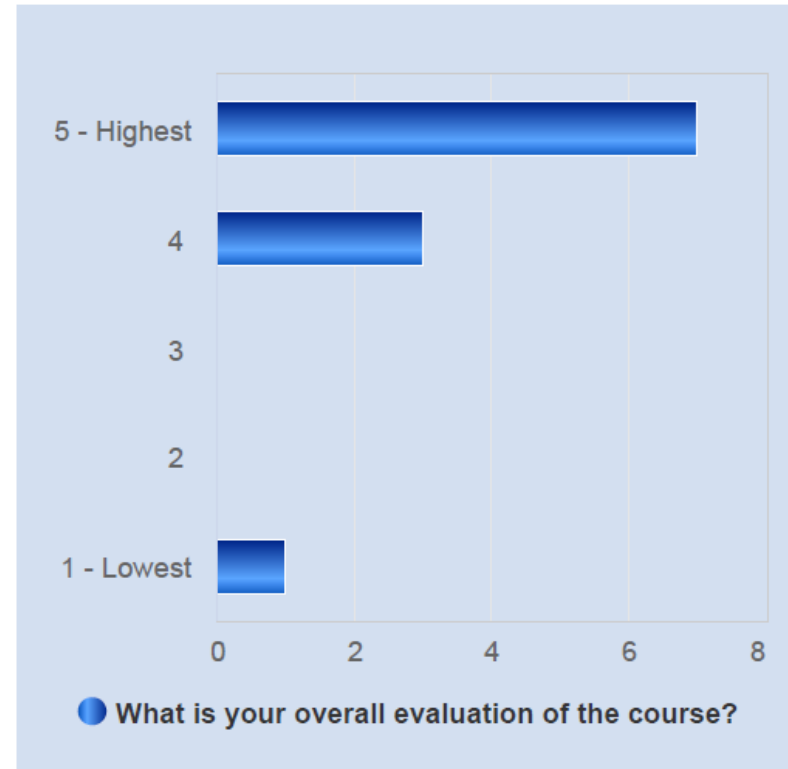
- 2 groups in 2 passes (A, B)
 - **Group A** (A1, A2), ~24 students in total
 - ▶ v45,46,47: Sehrish Qummar, Sajad Khosravi
 - ▶ v48,49,50: Ingemar Ragnemalm, Sajad Khosravi
 - **Group B** (B1, B2), ~24 students in total
 - ▶ v46-50: Sehrish Qummar, Sajad Khosravi
- We use the computers in ***Olympen*** (B-house, entry 25, upper floor)
- Work in **pairs**.
 - No singletons, please
- Sign up in **webreg** (www.ida.liu.se/webreg) by **this friday**
 - We reserve the right to compact and balance lab groups

Lab Series (3)

- **Mandatory presence! (ISY-style labs)**
- The lab room (Olympen) is reserved (and paid!) for our course during scheduled lab hours.
 - No guarantees of access/availability of Olympen / its computers outside scheduled lab hours.
- Demonstration / lab reports to lab assistant by the **deadlines**
 - CPU labs: last CPU lab session **22/11** resp. **24/11/2023** (soft), latest **13/12** resp. **14/12/2023 10:00** (hard)
 - GPU labs: last GPU lab session, **13/12** resp. **14/12/2023**
- Be well-prepared!
Supervised lab time is too costly for reading the instructions ...
- **No copying!**

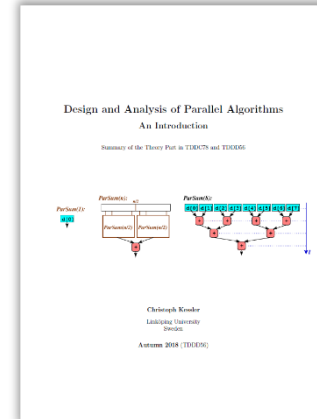
Changes Since 2022

- No major changes in contents / structure
 - The course evaluation was very good (4.36)



Course material and homepage

- All information available on the **course homepage**: www.ida.liu.se/~TDDD56
 - We do *NOT* use LISAM!
- **Course books / compendia:**
 - C. Kessler: ***Design and Analysis of Parallel Algorithms: An Introduction***. Compendium, (c) 2020.
 - ▶ PDF available for registered course participants. Not for general distribution.
 - ▶ Covers the 3 lectures on analysis of parallel algorithms and on parallel sorting, and the patterns introduction.
 - I. Ragnemalm: ***Attack in Packs***. Compendium, (c) 2018.
 - ▶ PDF available for registered course participants. Not for general distribution.
 - ▶ Covers the GPU lectures.
- Some slide sets and other material require **login/password**
 - Sent out to registered participants + guest participants
 - Please keep it secret
- **Lab assignments** on the course homepage

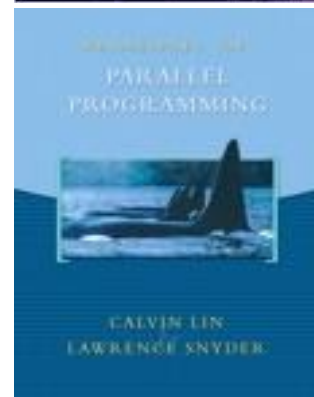
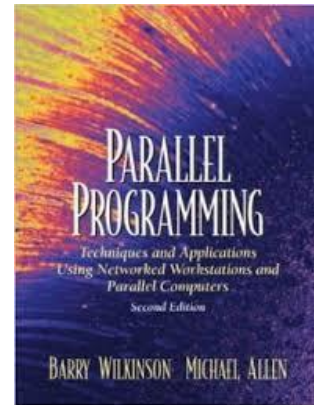


Introductory Literature (Selection)

If you already attended TDDC78, you need no other textbook on the general parallel computing / CPU part.

Otherwise, one of the following introductory books might be useful (available in the LiU library as refcopy and for loan):

- B. Wilkinson, M. Allen:
Parallel Programming, 2e.
Prentice Hall, 2005.
(general introduction; **Pthreads**, OpenMP, MPI;
also used in TDDC78)
- C. Lin, L. Snyder:
Principles of Parallel Programming.
Addison Wesley, 2008.
(general introduction; **Pthreads**)
 - Errata for the first printing:
<https://www.cs.utexas.edu/~lin/errata.html>



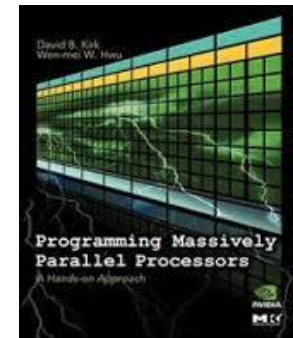
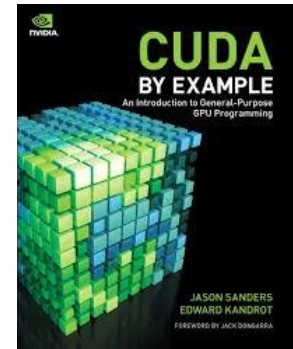
GPU Programming Literature

Focus on CUDA.

One of the following books might be useful:

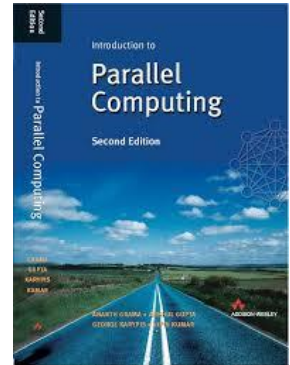
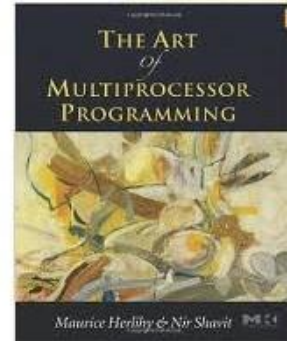
- J. Sanders, E. Kandrot: *CUDA by example*. Addison-Wesley, 2011. (recommended)
- David B. Kirk and Wen-mei W. Hwu: *Programming Massively Parallel Processors: A Hands-on Approach*. Morgan Kaufmann, 2010. Second edition 2012.

Available in the LiU library



Further Reading

- M. Herlihy, N. Shavit: *The Art of Multiprocessor Programming*. Morgan Kaufmann, 2008.
(threads; nonblocking synchronization)
- A. Grama, G. Karypis, V. Kumar, A. Gupta: *Introduction to Parallel Computing, 2nd Edition*. Addison-Wesley, 2003.
(design and analysis of parallel algorithms)
- ...



See the course homepage for further references

- Available in the LiU library
- **On-line references** on the course homepage

Another Master-Level Course ...

TDDC78 Programming of Parallel Computers, 6hp

- VT2 (March–May) every year
- Topics include:
 - Parallel computer architecture concepts, esp. clusters
 - Parallel algorithms for High-Performance Computing
 - Parallel thread programming with OpenMP (Labs)
 - Message passing programming of clusters with MPI (Labs)
 - Tools for performance analysis (Labs)
- Labs on Swedens largest (academic) supercomputer (or equivalent), at NSC
- A good complement of TDDD56