TDDC78

Programming of Parallel Computers - Methods and Tools

VT 2023

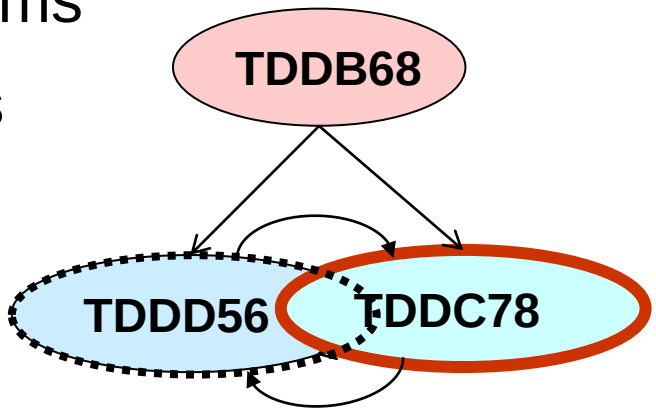
Course information and overview

Christoph Kessler, IDA

TDDC78 Contents

High Performance Computing (HPC)

- Basic concepts of parallel HPC computer architecture
- Parallel programming models, languages, and environments
  - Shared memory - Pthreads (prerequisite, e.g. TDDB68)
  - Shared memory - OpenMP
  - Distributed memory, message passing - MPI
- Design methods for parallel programs
- Design and analysis of parallel algorithms
- Parallel scientific computing algorithms
- Tools for programming and performance analysis



TDDC78 Staff VT 2023

- Christoph Kessler, IDA, christoph.kessler@liu.se
  Examiner + course leader
- Frank Bramkamp, NSC,
  Guest lecturer
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  Course assistant and lab assistant

- Course area manager (studierektor)
  Martin Sjölund, IDA martin.sjolund@liu.se
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TDDC78 Organization

Course web page

- http://www.ida.liu.se/~TDDC78

Structure

- Lecture series
- Lessons
- Lab series 3hp
- Written exam 3hp

TDDC78 Lecture plan (1)

Lectures 1-4: Parallel computer architecture concepts

- I: Distributed Memory, Clusters and Networks (CK)
- II: Memory Hierarchy; Shared Memory (CK)
- III: SIMD, Multithreading, Multicore, Accelerators, Hybrid Systems. Architectural Trends, TOP500 (CK)
- IV: Introduction to NSC systems (F. Bramkamp, NSC) and guided tour to NSC supercomputer hall

Lectures 5-6: Design of parallel programs (CK)

Lesson 1 (1h): Introduction to the lab series (SQ)

Lectures 7-8: Message passing with MPI (CK)

Lectures 9-10: Shared-memory multithreading with OpenMP (CK)

TDDC78 Lecture plan (2)

Lecture 11: Tools for performance analysis (CK)

Lecture 12-13: Design and analysis of parallel algorithms (CK)

Lectures 14-15: Parallel Linear Algebra Algorithms (CK)

Parallel Basic Linear Algebra Algorithms,
Parallel Solving of Linear Equation Systems,
Data distribution and PGAS languages

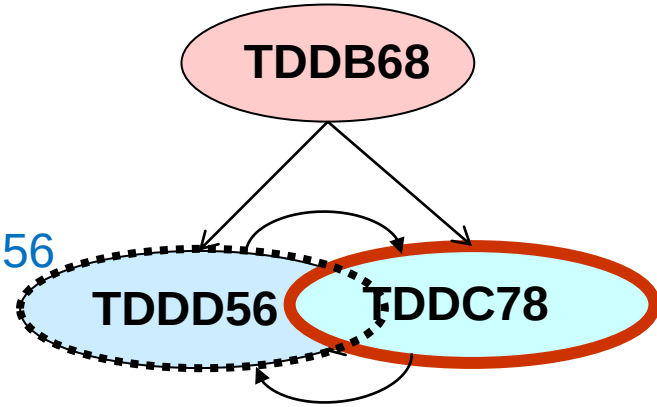
Lesson 2: Exam training (CK)

Lecture 16: Loop optimization and parallelization (CK)

NB no one-to-one mapping to schedule slots

Lectures/Topics in blue color overlap with
TDDD56 Multicore and GPU Programming
and are optional for students who have taken TDDD56

NSC guest lecture and Lesson 1 are mandatory.



TDDC78 Labs (1)

- **NSC supercomputer platforms**
  - MPI, pthreads, OpenMP and tools on Linux cluster "**Sigma**" https://www.nsc.liu.se/systems/sigma
    - Sigma is the "little brother" of "Tetralith" https://www.nsc.liu.se/systems/tetralith
    - Same type of hardware and software environment
  - Part of Sigma is reserved for our course during scheduled lab hours

No.	Lab	Platform
1a 1b	Image filter	Pthreads MPI
2	Stationary heat conduction	OpenMP
Miniproject	Particle simulation	MPI (Tools ddt + ITAC mandatory)

Labs (2)

- **Working in pairs** (if possible)
  - Both be prepared for each lab session!
  - Need both be able to explain all your own code

- **2 passes**:
  - Group A (Sehrish Qummar): 2 rooms, 9 teams of 2 students
  - Group B (Sehrish Qummar): 2 rooms, 9 teams of 2 students

  Register for a lab group via **webreg** by **31 March 2023**

  We reserve the right for group compaction and rebalancing.

  Attend your group's scheduled lab passes only.

  Reserved partition of Sigma during scheduled hours only

- **Lab deadline**: Day of last lab session of A, B
  - See the lab page and lab intro for soft deadlines for each lab

- **No copying!** Cheating will be taken seriously.

Important steps

- Proper **course registration** for TDDC78 required
  - If not registered, contact the director of studies ASAP!
- **Follow the instructions on the course homepage** to
  - create an account in SUPR
    - Requires that you have a valid LiU-ID
  - then request membership in the course project (LiU-compute-2023-9)
  - then request an account on Sigma
    - and accept the User Agreement.
  - Completely electronic procedure, instructions on web page
  - Do this by **31 March 2023**
- Register for a lab group in webreg by 31 March 2023.
- **Mandatory**: the **NSC introduction** lecture (wednesday 15:15-16:00) and **Lesson 1** (lab introduction)

Examination

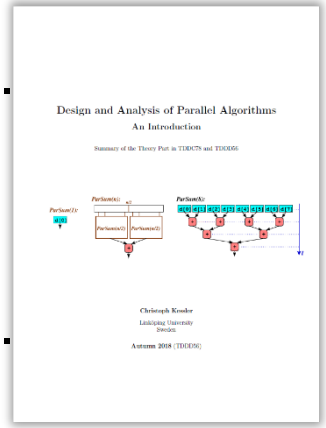
- **Lab series**, 3 hp (ECTS)
  - Deadline: Day of the last lab session (A, B)

- **Written exam**, 3 hp (ECTS)
  - First opportunity: 1 June 2023 08:00-12:00
  - Don’t forget exam registration – deadline 10 days before
    - LiU rule - no way to get registered after that

Course literature

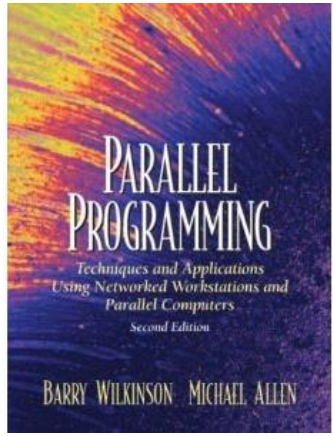
Mandatory

- C. Kessler: *Design and Analysis of Parallel Algorithms: An Introduction*. Edition spring 2020. (May be updated 2023 if time permits.)
  - Available for registered students on the course homepage. Login + password was sent out by e-mail.
- L. Eldén et al.:
  Scientific Computing on High Performance Computers, 2008.
  - Available for registered students on the course homepage.
- Lab compendium. Online.



Complementary Reading

- B. Wilkinson, M. Allen: *Parallel Programming*, 2nd ed., Prentice Hall, 2005. (LiU library)
- G. Hager, G. Wellein: *Introduction to High-Performance Computing for Scientists and Engineers*. CRC Press, 2010. e-book (LiU library).



Additional references and online articles

- on the course webpage http://www.ida.liu.se/~TDDC78