



**TDDC78**

**Programming of Parallel Computers  
- Methods and Tools**

**VT 2022**

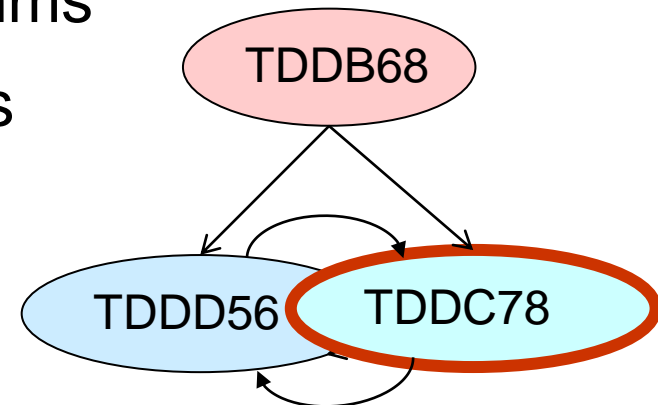
**Course information and overview**

**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. TDDDB68)
  - 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 2022

- Christoph Kessler, IDA, Examiner + course leader christoph.kessler@liu.se
- Frank Bramkamp, NSC, Guest lecturer
- August Ernstsson Course assistant and lab assistant august.ernstsson@liu.se
- Andreas Lindsten Lab assistant andli035@student.liu.se
- Course area manager (studierektor) Martin Sjölund 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)

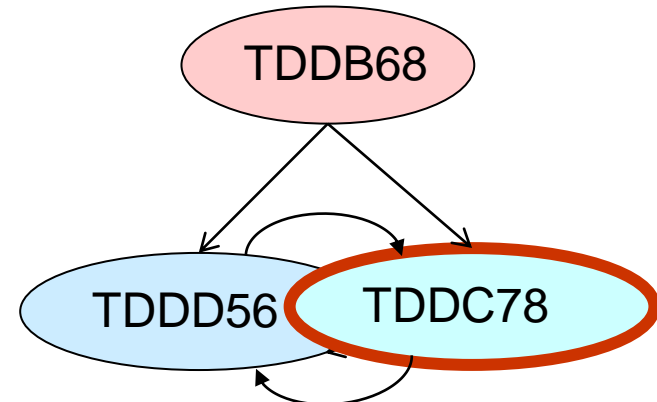
- Parallel computer architecture concepts I:  
Distributed Memory, Clusters and Networks (CK)
- Parallel computer architecture concepts II:  
Memory Hierarchy; Shared Memory (AE)
- SIMD, Multithreading, Multicore, Accelerators, Hybrid Systems.  
Architectural Trends, TOP500
- Guest Lecture: Introduction to NSC systems (F. Bramkamp, NSC)  
and guided tour to NSC supercomputer hall
- Design of parallel programs I (CK)
- Design of parallel programs II /  
MPI I (CK)
- MPI II (CK)
- MPI III / OpenMP I (CK)
- OpenMP II (1h) + Lesson 1 (1h): Introduction to the lab series (AE)

# TDDC78 Lecture plan (2)

- OpenMP III, Advanced issues OpenMP + MPI; Tools for performance analysis (CK)
- Design and analysis of parallel algorithms I (CK)
- Design and analysis of parallel algorithms II; Fundamental (data)parallel algorithms (CK)
- Parallel Linear Algebra Algorithms I (CK)
- Parallel Linear Algebra Algorithms II (CK), Parallel Solving of Linear Equation Systems (CK); Data distribution and PGAS languages (CK)
- Lesson 2: Exam training (AE)
- Loop optimization and parallelization (CK)

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 (Andreas Lindsten, August Ernstsson):  
 $\leq 2$  rooms x 5x2 in parallel
  - Group B (August Ernstsson, Andreas Lindsten):  
 $\leq 2$  rooms x 5x2 in parallel

Register for a lab group via **webreg** by **1 April 2022**

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 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-2022-5](#))
  - then request an account on Sigma
    - and accept the User Agreement.
  - Completely electronic procedure, instructions on web page
  - Do this by **1 April 2022**
- Register for a lab group in webreg by 1 April 2022.
- **Mandatory:** the **NSC introduction** lecture (wednesday 15:15-16:00) and **Lesson 1** (lab introduction)

# Examination

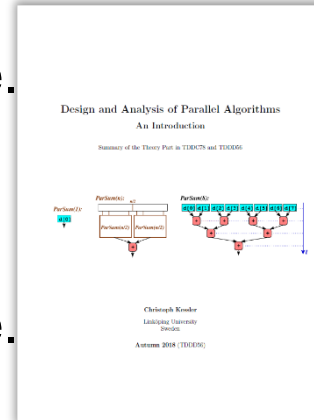
- **Lab series**, 3 hp (ECTS)
  - Deadline: Day of the last lab session (A, B)
- **Written exam**, 3 hp (ECTS)
  - First opportunity: 2 June 2022 14:00-18:00
  - Don't forget exam registration – deadline 10 days before
    - New LiU rule - no way to get registered after that



# Course literature

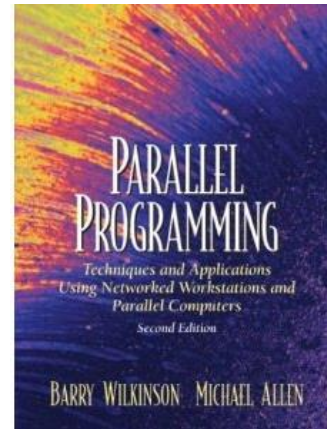
## Mandatory

- C. Kessler: *Design and Analysis of Parallel Algorithms: An Introduction*. Edition spring 2020. May be updated 2022 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>