# TDDD56
# Multicore and GPU Programming

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2018

**LINKÖPING UNIVERSITY**

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## Staff 2018

- **Christoph Kessler**, IDA — christoph.kessler (at) liu. se
  - Organization, most lectures, examinator
- **Ingemar Ragnemalm**, ISY — ingemar.ragnemalm (at) liu. se
  - Lectures on GPU programming, GPU labs
- **August Ernstsson**, IDA — august.ernstsson (at) liu. se
  - Course assistant, lessons, CPU labs
- **Alexander Wilkens** — alewi684 (at) student. liu. se
  - Lab assistant CPU+GPU labs
- **Carita Lilja**, IDA — carita.lilja (at) liu. se
  - Course secretary (Ladok reporting)
- **Ola Leifler**, IDA — ola.leifler (at) liu. se
  - Director of undergraduate studies

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## Are you registered on TDDD56?

- Currently, the course is full (limit: 64).

  65 were registered by 21 august when the course was closed
  - If taking the course this year, please register for the labs by friday this week
  - 12 currently on the waiting list

- Non-registered (21/8) students please join the **waiting list** if not done yet.
  - Wait with Ladok and webreg registration
  - Notification about admission on sunday after the first week
  - No labs nor exam correction without valid course registration
  - Attending lectures and lessons is always possible

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## Course Moments

- Lectures
- Lessons (mandatory for the labs)
- 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

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## Lectures (1)

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

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## 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. (AE)
  *Please solve suggested exercises in advance to be prepared.*
- **Lecture 14:** Parallelization of sequential programs*. (CK)

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## Lab Series (1)

**CPU-labs** (week 46, 47, 48)
- Lab 1: Load balancing (warm-up)
- Lab 2: Nonblocking synchronization
- Lab 3: Skeleton programming; Median filtering

**GPU-labs** (week 49, 50, 51)
- Lab 4: CUDA 1
- Lab 5: CUDA 2
- Lab 6: OpenCL and Shader programming

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## Lab Series (2)

- 2 groups in 2 passes (A, B)
  - **Group A** (32 students) = **A1** (16st) || **A2** (16st)
    - v46-48: August Ernstsson (A1) + Alexander W (A2)
    - v49-51: Ingemar Ragnemalm (A1) + Alexander W (A2)
  - **Group B** (32 students) = **B1** (16st) || **B2** (16st)
    - v46-51: August Ernstsson (B1) + Alexander W (B2)
- All lab sessions in *Signal-och-Bild-Labbet* (B2C:525A)
  - Temporary solution for 2018 only
- Work in pairs. No singletons – the course is full.
- Sign up in **webreg** (www.ida.liu.se/webreg) by **this friday**
  - We reserve the right to compact and balance groups

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## Lab Series (3)

- **Mandatory presence!** (ISY-style labs)
- The room (System-och-Bild-labbet) is reserved for our course during scheduled lab hours.
  - No guarantees outside scheduled lab hours.
  - Locked outside supervised lab hours.
- Demonstration / lab reports to lab assistant by the deadlines
  - CPU labs: 29/11/2018 (soft), **20/12/2018 18:00** (hard)
  - GPU labs: last lab session, **19/12 resp. 20/12/2018**
- Be well-prepared!
  Supervised lab time is too costly for reading the instructions …
- **No copying!**

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## Course material and WWW homepage

- All information available on the **course homepage:**
  www.ida.liu.se/~TDDD56
- **Course books / compendia**:
  - C. Kessler: *Design and Analysis of Parallel Algorithms: An Introduction.* Compendium, (c) 2018.
    - Available for registered participants of TDDD56 (2018). Not for general distribution.
    - Covers the 3 lectures on analysis of parallel algorithms and on parallel sorting.
  - I. Ragnemalm: *Attack in Packs.* Compendium, (c) 2018.
    - Available for registered participants of TDDD56 (2018). 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

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## Introductory Literature (Selection)

If you already attended TDDC78, you need no textbook on the general / 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.
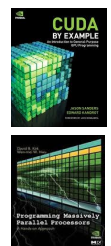  (general introduction; Pthreads)

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## 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

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## 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

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## 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 (new 2018) (academic) supercomputer, at NSC
- A good complement of TDDD56

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