Time and location

Time:	Wednesday 11:30 – 13 h
Start date:	April 23, 2025
Location:	HS 93, Bldg. 10.81

Contact (by appointment)

Location:	Room 122, Bldg. 10.81
Phone:	0721-608 47245
Email:	`markus.uhlmann@kit.edu`

Aim and scope of this course

- To convey the basic knowledge about parallel computing possibilities and its limitations.
- To enable the students to analyze a given problem from CFD (and beyond) and assess the potential for an efficient solution using parallel computing techniques.
- To transmit the scope, syntax and practical application of the message passing paradigm, using the standard "MPI" (message passing interface).

Course material

Available via ILIAS. Please susbscribe to this course under the following URL:
`https://ilias.studium.kit.edu/goto.php?target=crs_2645001`

Prerequisites

- **MANDATORY: good programming skills in either Fortran or C/C++!**
  Please **test yourself** with the pre-course programming problem sheet available in ILIAS. If this assignment is too demanding, please follow an introductory programming course first.
- Please bring your own laptop (install: compiler, MPI libraries; hints available in ILIAS).

Exam

Oral exam, 30 minutes. Next exam date: **August 11, 2025.**
Please register before the end of the lecture period (by **August 1, 2025**). If not possible online, this must be done by contacting the secretariate (A. Fels).

Planning and content of the course

Lecture 1 (23.4.): General introduction to parallel programming
Background on hardware; software paradigms; measuring efficiency; network topologies.

Lecture 2 (30.4.): General introduction to MPI "`hello world!`"

Lecture 3 (7.5.): MPI point-to-point communication "`send/recv, latencyBW`"

~~**(14.5.)**~~

Lecture 4 (21.5.): Case study – parallel search problem "`search`"

Lecture 5 (28.5.): MPI collective communication "`pi`"

Lecture 6 (4.6./~~11.6.~~/18.6.): Case study – 2D Poisson solver "`jacobi`"

Lecture 7 (25.6./2.7): Non-contiguous data & mixed datatypes "`search`"

Lecture 8 (9.7.): Virtual topologies & Communication subsets "`search`"

Lecture 9 (16.7./23.7.): Use of linear algebra libraries – dense linear system solver "`scaex`"

Lecture 10 (30.7.): Some examples of parallel applications – Navier-Stokes solvers
Parallel wavelet transform; spectral methods for DNS of single-phase flow; finite-difference method for particulate flow DNS.

Further Ressources

- NCSA online courses on parallel programming and MPI:
  `http://www.citutor.org/users/index.php` (choose "Introduction to MPI")
- A complete reference of the MPI library standard is available at NETLIB:
  `http://www.netlib.org/utk/papers/mpi-book/mpi-book.html`
- A useful short summary of the syntax and use of each MPI command can be accessed at the following URL:
  `http://www-cfd.ifh.uni-karlsruhe.de/uhlmann/mpi2/www/index.html`
- The user guides for SCALAPACK and BLACS are also available at NETLIB:
  `http://www.netlib.org/scalapack`

References

[1] N. Carriero and D.H. Gelernter. *How to write parallel programs: a first course*. MIT Press, 1990.
[2] T.G. Mattson, B.A. Sanders, and B.L. Massingill. *Patterns for Parallel Programming*. Software Patterns Series. Pearson Education, 2004.
[3] M. Snir. *MPI - The Complete Reference: Volume 1, the MPI Core*. Scientific and Engineering Computation Series. Mit Press, 1998. URL.
[4] A. Grama, A. Gupta, G. Karypis, and V. Kumar. *Introduction to Parallel Computing*. Pearson Education. Addison-Wesley, 2003.