



Parallel Programming with MPI and OpenMP

*Universidad Autónoma de Madrid
30 de noviembre al 4 de diciembre de 2015*

Abstract: The objectives of this course are to understand and practice the fundamental concepts of Parallel Programming with Message Passing and Shared Memory. The course covers the two widely used programming models: MPI for distributed environments, and OpenMP for shared-memory architectures. It also presents some tools providing support in the development of parallel applications. The Debugger, to find the causes for application errors; Paraver, to be able to analyze the behaviour of the parallelism; and Tareador, to extract task parallelism from applications. The course is taught using formal lectures, combined with practical/programming sessions.

Attendees are expected to have some theoretical and practical knowledge in programming.

Day 1

Session 1 9:00 – 13:00 Janko Strassburg

1. Introduction to parallel architectures, algorithms design and performance parameters
2. Introduction to the MPI programming model
3. Practical:
 - Installation of MPI libraries
 - How to compile and run MPI applications

Session 2 14:00 – 18:00 Janko Strassburg

1. MPI: Point-to-point communication, collective communication
2. Practical: Simple matrix computations
3. MPI: Blocking and non-blocking communications
4. Practical: Communication examples

Day 2

Session 1 9:00 – 13:00 Janko Strassburg

1. MPI: environment variables influencing MPI execution
2. MPI: Collectives, Communicators, Topologies, Resiliency
3. Practical: Heat equation example
4. Parallel debugging, options from print to strace to Valgrind to GDB
5. Practical
 - Installation of debugging tools
 - Use of the tools with the MPI applications
6. Use of HPC machines, preparing and submitting jobs. Slurm, parallel filesystems

Session 2 14:00 – 18:00 Vladimir Subotic

1. Introduction to Paraver: tool to analyze and understand performance
2. Practical:
 - Installation of Paraver and Extrae
 - Examples with MPI: Trace generation, visualization and analysis
 - Explicit calls to Extrae user events
 - Manual construction of Paraver configuration files

Day 3

Session 1 9:00 – 13:00 Vladimir Subotic

1. Advanced Paraver tutorial
 - Performance studies of complex MPI applications

Session 2 14:00 – 18:00 Vladimir Subotic

1. Tareador: Understanding and predicting the potential of task decomposition strategies
2. Practical:
 - Installation of Tareador
 - Exploring parallelism with Tareador: dot-product, heat diffusion and multisort

Day 4

Session 1 9:00 – 13:00 Xavier Martorell / Xavier Teruel

1. Shared-memory programming models, OpenMP fundamentals
2. Parallel regions and work-sharing constructs
3. Synchronization mechanisms in OpenMP
4. Practical:
 - Compilation and linking with OpenMP
 - Heat diffusion in OpenMP

Session 2 14:00 – 18:00 Xavier Martorell / Xavier Teruel

1. Tasking in OpenMP 3.0 and 4.0
3. Practical:
 - Heat diffusion
 - Multisort
 - Cholesky

Day 5

Session 1 9:00 – 13:00 Xavier Martorell / Xavier Teruel

1. Programming with hybrid MPI/OpenMP
2. Practical:
 - Matrix multiply in Hybrid MPI/OpenMP
 - Heat example in Hybrid MPI/OpenMP

Session 2 14:00 – 18:00 Xavier Martorell / Xavier Teruel

1. Advanced programming with OpenMP
2. Practical: Examples of SIMD and NUMA placement