Course Objectives

FORTRAN is one of the principal languages used in scientific, numerical and engineering programming and knowledge in FORTRAN is an indispensible qualification for students, researchers, and engineers. With the two recent revisions of the language, the power of the language has been progressively enhanced, and most vendors (IBM, HP, SGI, Intel, Sun, Cray) provide highly optimizing FORTRAN compilers, based on more than 50 years of experience.

MPI (Message Passing Interface) is the de-facto standard for programming portable message-passing parallel applications on networked computers (also known as clusters). MPI has bindings to C/C++ and FORTRAN, and it is available on all massively-parallel supercomputers.

OpenMP (Open Multi-Processing) is a standard application programming interface (API) that supports multi-platform shared memory multiprocessing programming in C/C++ and FORTRAN. It consists of a set of compiler directives, library routines, and environment variables that enable shared memory parallelism and execution.

The current and the future supercomputers consist of a cluster of computers (nodes) each with multiple processing cores (dual, quad, multicore) that share the memory of the node.

The goal of the course it to outline strategies for porting and writing efficient, portable, maintainable code for such hybrid computer archictectures.

Learning Objectives

A student who has met the objectives of the course will be able to:

- read programs written in FORTRAN
- write programs in FORTRAN
- read programs with OpenMP directives
- write programs with OpenMP directives
- read programs using MPI
- write programs using MPI
- understand the difference between shared and distributed memory paralleism
- perform serial benchmarking of code
- perform code debugging
- measure parallel efficiency
- use Amdah's law

Contents

The Ph.D. course consists of 3 parts:

Part I: Programming FORTRAN
Part II: Introduction to OpenMP
Part III: MPI

Language

All lectures will be given in English

Organizers

Jens Honore Walther, 403, 216, (+45) 4525 4327, jhw@mek.dtu.dk
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This course is offered as part of the activities of the DCAMM International Graduate Research School, see www.dcamm.dk.

Internet resources

For information about teaching and research at the DCAMM departments: see http://www.dcamm.dk.
For facts on the Technical University of Denmark and visitor's information see: http://www.dtu.dk
For information on the University of Aalborg see: http://www.aau.dk.

Participants

The course is designed for Ph.D. students and final-year Graduate students being familiar with the basic concepts of Scientific Computing. Some experience with programming and unix/linux is required.

Work Load

The PhD. course consists of 2-3 hours lecture per day and 2-3 hours exercises during the 3-week period.

Study Material

FORTRAN: Michael Metcalf, John Reid, and Malcolm Cohen. FORTRAN 95/2003 Explained, Oxford University Press, 2004

OpenMP: B. Chapman, G. Jost, R. vand der Pas. Portable Shared Memory Parallel Programming.

MPI: Handouts and the MPI report: http://www.mpi-forum.org/docs/mpi-1.3/mpi-report-1.3-2008-05-30.pdf

Evaluation and Diplomas

To pass the course, active participation in all activities is required, as well as submission of required exercises and reports.

Grades: Pass/Fail. ECTS points: 5.

Registration:

Ask for a registration form from the DCAMM-course secretariat, attn.: Kari Haugland, Department of Mathematics, Technical University of Denmark, Building 303S, DK-2800 Lyngby, Denmark. Tel.: (+45) 45253031, Fax: (+45) 45881399, E-mail: dcamm@mat.dtu.dk.

Registration fee:

There is no registration fee for students enrolled at universities and public research institutions. For researchers employed at universities and public research institutions the registration fee is 500 EURO. This covers hand-outs, coffee and social events. For all other participants the registration fee is 1500 EURO.

Deadline:

Applicants should submit their registration to course secretariat no later than December 15th, 2008. You will receive confirmation within a week after this date.

Housing:

There are a limited amount of rooms available on the premises of the Technical University of Denmark (DTU). These will be offered free of charge to students and otherwise at a cost of 25 EURO per night. Accommodation in hostels/hotels can also be arranged by the participants themselves, see the Wonderful Copenhagen website at www.woco.dk.

Scholarships:

For Ph.D.-students enrolled at non-Danish universities and research institutions outside the EU, we can offer a limited number of scholarships in order to facilitate participation, covering lodging (see above) and extra living costs with a per diem amount of 25 EURO. Travel expenses will not be covered. Your CV and a short letter of recommendation from your Ph.D.-supervisor should be sent in together with the application form.

Program

Week 1:
=======
Monday, January 5th:
08:30 - 09:00 Registration, coffee and rolls.
09:00 - 09:15 Welcome.

Monday, January 5th - Friday, January 9th:
09:15 - 12:00 FORTRAN
12:00 - 13:00 Lunch break
13:00 - 16:00 Exercises

Week 2:
=======
Monday, January 12th - Friday, January 16th:
09:15 - 12:00 OpenMP
12:00 - 13:00 Lunch break
13:00 - 16:00 Exercises

Week 3:
=======
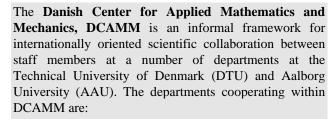Monday, January 19th - Friday, January 23th:
09:15 - 12:00 MPI
12:00 - 13:00 Lunch break
13:00 - 16:00 Exercises

The **Danish Center for Applied Mathematics and Mechanics, DCAMM** is an informal framework for internationally oriented scientific collaboration between staff members at a number of departments at the Technical University of Denmark (DTU) and Aalborg University (AAU). The departments cooperating within DCAMM are:

- Dept. of Informatics & Mathematical Modelling, DTU
- Dept. of Mathematics, DTU
- Dept. of Mechanical Engineering, DTU
- Dept. of Civil Engineering, AAU
- Dept. of Mechanical Engineering, AAU

DCAMM is an informal construction. The day to day activities are coordinated by the secretary of the Center, while the formal governing body of DCAMM is the Scientific Council.

The **DCAMM International Graduate Research School** functions within the standard framework of the Ph.D. education at the Technical University of Denmark (DTU) and at Aalborg University (AAU). Ph.D.-students associated to the School are full members of DCAMM through their departments and are enrolled in relevant Ph.D.-programmes at DTU and AAU.

The School's role is to provide for an interdisciplinary framework for education of young researchers in an international research environment, and the activities are supported by Danish Agency for Research, Technology and Innovation (FUU).

DANISH CENTER FOR APPLIED MATHEMATICS AND MECHANICS

Ph.D.-course / Advanced school
Course no.41391

High Performance Computing: FORTRAN, OpenMP and MPI

at

Technical University of Denmark,
Lyngby, Denmark

January 5th – 23th, 2009

Organized by:
Department of Mechanical Engineering,
Technical University of Denmark

Technical University of Denmark University of Aalborg

DTU
AALBORG UNIVERSITET