



## **HECTOR course syllabus: “Parallel Programming with MPI”**

### *Introduction to HPC*

What is HPC?; basic terminology and concepts; architectural classifications; memory classification; types of supercomputer and major vendors.

### *Introduction to Parallel Programming*

Parallel decomposition; message passing (MPI); shared memory parallel computing (OpenMP); MPI, OpenMP or hybrid MPI/OpenMP?; other languages for parallel processing; batch systems.

### *Introduction to MPI*

The MPI standard; MPI\_Init and MPI\_Finalize; rank and size; error checking; basic code checklist and templates; linking and running MPI codes.

### *Point-to-point Communication Part 1*

The MPI\_Send and MPI\_Recv calls; MPI datatypes; blocking communication and deadlocks; the MPI\_Sendrecv call; other types of blocking send.

### *Timing Programs*

The MPI\_Wtime and MPI\_Wtick calls.

### *Point-to-point Communication Part 2*

Non-blocking communication; the calls MPI\_Isend, MPI\_Irecv, MPI\_Wait and MPI\_Test.

### *Collective Communication*

Barriers; broadcasts; gathering and scattering data using MPI\_Gather and MPI\_Scatter; reduction operations; non-blocking collective communication.

### *Message Passing Numerical Libraries*

A short overview of message passing numerical libraries, including PBLAS, ScaLAPACK and FFTW.

## *The HECToR Service*

The HECToR service; hardware; software; getting time on HECToR; the HECToR CSE service.

## *MPI Derived Datatypes*

Committing and freeing MPI derived datatypes; constructing MPI datatypes for contiguous and strided arrays; constructing MPI datatypes for Fortran types and C structures.

## *User-Defined Binary Operators*

How to define a binary operator for use in reduction routines.

## *Cartesian Topologies*

Defining a Cartesian topology using `MPI_Cart_create`; topology inquiries; converting between Cartesian coordinates and ranks; shifting data using `MPI_Cart_shift`; neighbourhood collectives.

## *Groups and Communicators*

Groups and communicators; communicator constructors: duplicating and splitting communicators; inter-communicators.

## *Background Reading*

It is not essential to do any reading in advance of the course but the following references may be useful.

1. MPI Standard Documents, <http://www.mpi-forum.org/docs/docs.html>
2. Gropp, Lusk and Skjellum, "Using MPI: Portable Parallel Programming with the Message-passing Interface (Scientific and Engineering Computation)", MIT Press, second edition.