

**Summary of
Heterogeneous Computing - Many Core/ Multi GPU
- Performance of Algorithms, Application Kernels
(HeMPa – 2011)**

Centre for Development of Advanced Computing (C-DAC) Pune and Centre for Modeling Simulation and Design (CMSD), University of Hyderabad, jointly conducted **five** days technology workshop titled “**Heterogeneous Computing - Many Core/ Multi GPU – Performance of Algorithms, Application Kernels (HeMPa – 2011)**” at CMSD, University of Hyderabad, during the period October 17-21, 2011.

One of the objectives of **HeMPa-2011** technology workshop was to understand software multi-threading and performance issues for large-scale application kernels on multi-core processors, develop expertise in distributed shared memory programming i.e. Partitioned Global Address Space (PGAS) memory model, develop GPU programs for numerical computations on GPGPU based systems (CUDA/OpenCL enabled NVIDIA GPUs & AMD-APP- OpenCL) as well as on High-Performance Computing (HPC) GPU cluster based on different programming paradigms on host GPU and device GPU.

The second objective was to understand how to design and write application kernels for numerical & non-numerical computations on heterogeneous parallel processing platforms from application perspective. The **five days** workshop provided an opportunity for interaction among the various participants from different academic institutes and research organizations in the country and leading IT company experts who are working in the area of emerging heterogeneous parallel processing platforms. By understanding the HemPa-2011 hard-copy and softcopy CD as building blocks, scientists and engineers could piece together more complicated software tools that are tailored specifically for their needs, emerging parallel processing platforms using Multi-Core Processors with PGAS, GPGPUs / and HPC GPU Clusters..

The **HeMPa-2011** technology workshop provided strong foundation in order to solve performance of large-scale scientific and engineering applications on Multi-Core Processors using Shared memory programming and PGAS Model , HPC-GPU Cluster (CUDA enabled NVIDIA GPUs /OpenCL NVIDIA/AMD-APP) platforms and Heterogeneous computing systems.

The **HeMPa-2011** technology workshop CD soft-copy proceedings offer the application users a great opportunity to learn about the fundamentals of writing parallel programs using different programming paradigms. The proceedings, and hands-on (CD) soft-copy is developed in order to impart a sense of unity to this expanding and exciting field of emerging heterogeneous parallel processing technologies. The HeMPa-2011 laboratory session is provided foundation for application user to implement parallel algorithms for

heterogeneous computing platforms such as Multi-Core processor platforms with PGAS memory models and HPC Cluster computing systems with GPUs.

The **HeMPa-2011** workshop is organized in two modes in which participants can attend 5-days programs (both mode-1 & Mode-2) or exclusively Mode-2 Programme. The workshop is designed for Mode 1 on October 17-18, 2011 for two days and Mode 2 on October 19-21 for three days. The **five days** workshop is aimed to cover classroom lectures in morning/forenoon session and four hours hands-on in afternoon session on distributed Shared memory platforms and HPC GPU Cluster on each day. The rich set of codes is provided on various computing platforms to understand and address performance issues of different codes that are written for this workshop. Participants will get an opportunity to walk-through and execute some of the programs designed for Mode 1 and Mode 2 of this workshop.

Mode-1 (Day 1-2) : The first two days i.e. 1st & 2nd day of Mode-1 of the **HeMPa-2011** workshop will give insights into performance aspects of software threading using different programming paradigms on Multi-Core processors as well as programming in Partitioned Global Address Space (PGAS) models. The sessions include six classroom lectures on Multi-Core processors and PGAS memory models Three keynote lectures on emerging topics of Multi-Core processors and PGAS memory model from application perspectives are be covered. The laboratory session of first two days i.e 1st & 2nd days of this workshop will give insights into performance aspects using different programming paradigms based on Distributed Memory Models, Shared Memory Models, and Distributed Shared Memory Models (PGAS).

Mode-2 (Day 3-5) : The 3rd , 4th and 5th day (Mode-2) of **HeMPa-2011** workshop will cover an overview of GPU Computing - CUDA Programming Software toolkit with Hands-on Session, GPGPUs - AMD-APP (SDK) with Hands-on Session, Programming on HPC GPU Cluster and an overview of Open Computing Language (OpenCL) as well as demonstration of software by Industry experts. Participants will use Multi-Core Processors, and Systems with GPGPUs / GPU accelerator devices and Hybrid Heterogeneous HPC GPU Cluster. HeMPa-2011 (Mode-2) programme is aimed to write programs on HPC GPU Cluster to solve compute intensive applications. The programming on heterogeneous computing systems (CPU/GPU) is based on CUDA & OpenCL which is quite useful to solve prototype applications Experts from Private Sector demonstrate programming based on GPUs on 3rd , 4th & 5th day of **HeMPa-2011** workshop.

The **HeMPa-2011** technology workshop is provided coding competition challenge for participants in collaboration with private IT sector HPC companies. These efforts can quickly understand programming and performance aspects of heterogeneous computing systems with multiple GPUs from application point of view.

C-DAC views the **HeMPa-2011** technology workshop Proceedings (CD proceedings) and the Hands-on session softcopy presentation notes as a continuously evolving resource on emerging parallel processing platforms. Hand-on Session softcopy document offers the application users a great opportunity to learn about the fundamentals of writing multi-threaded programs using different programming paradigms, emphasizing on optimization techniques to extract the performance on Multi-Core Processor Platforms, HPC Cluster Computing systems with GPUs. Most of the articles of the notes include broad coverage of practical aspects of emerging parallel processing platforms and have been selected from several important research articles, books and web sites. The material is prepared from various references that are included in the web-page.