

**Summary of  
Heterogeneous Computing - CPU/GPU HPC Cluster – Algorithms &  
Performance of Application Kernels (HeGaPa-2012)”  
(Initiatives on Power Efficiency - Green Computing)**

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 - CPU/GPU HPC Cluster – Algorithms & Performance of Application Kernels (HeGaPa-2012) (Initiatives on Power Efficiency - Green Computing)**” at CMSD, UoH during the period **July 16-20, 2012**.

The aim of the **HeGaPa-2012** technology workshop was to develop expertise on GPU Programming on HPC GPU cluster based on OpenACC compiler directives, programming paradigms on host CPU (MPI, OpenMP) and device GPUs (CUDA, OpenCL). The second objective was to understand how to design and write application kernels for numerical linear algebra (NLA) algorithms and application kernels 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 **HeGaPa-2012** 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 GPGPUs / and HPC GPU Clusters..

The **HeGaPa-2012** 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 **HeGaPa-2012** laboratory session is provided foundation for application user to implement parallel algorithms for heterogeneous computing platforms such as HPC Cluster computing systems with GPUs. The workshop proceedings provide a balanced coverage of theoretical and practical aspects on emerging trends in parallel processing platforms, performance enhancement through software multi threading, GPGPUs & GPU Computing - CUDA enabled NVIDIA GPUs, NVIDIA-PGI-OpenACC- Compiler Directives, GPGPUs AMD-APP SDK, and HPC GPU Cluster – different programming on host-CPU and CUDA / OpenCL Programming on device-GPU. Exhaustive hands-on session is made available to address CUDA, OpenACC and OpenCL programming on Heterogeneous Computing platforms.

The workshop is organized in **four modes** focusing on various programming paradigms of HPC GPU Cluster. 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**, **Mode-2**, and **Mode-3** of this workshop and the programs given in **Mode-4** are focused on application kernels.

The **Mode-1** gives insights into performance aspects of software threading using different programming paradigms on Multi-Core processors. The **Mode-2** and **Mode-3** 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 and exposure to the CUDA enabled NVIDIA GPU OpenACC (PGI) – Compiler Directives. It 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 and OpenCL which is quite useful to solve prototype applications. Experts from Private Sector demonstrate software and hardware components based on HPC GPU Cluster.

The **HeGaPa-2012** 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 **HeGaPa-2012** 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-pages.