

## **Summary of Performance Enhancement on Multi-Core Processors & GPUs (PEMG-2010)**

Centre for Development of Advanced Computing (C-DAC), Pune and C-DAC, Mumbai & Electronics City jointly conducted a four-day technology workshop titled "Performance Enhancement on Multi-Core Processors & GPUs (**PEMG-2010**)" held at C-DAC Electronics City, Bengaluru during the period June 21-24, 2010.

One of the objectives of **PEMG-2010** was to understand software multi-threading on Multi-Core Processors, GPU Computing using CUDA enabled NVIDIA, and GPGPU-Stream Computing SDK Accelerators, OpenCL programming, Hybrid (Heterogeneous) Computing and Multi-Core Processor Clusters. The second objective is aware of performance enhancements through software multithreading on Multi-Core Processors, GPU computing, and GPGPU – Stream Computing for solving large-scale problems in Scientific and Engineering and Commercial domains. The four-day 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.

**PEMG-2010** 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 parallel processing technologies. The **PEMG-2010** laboratory session programs provide foundation for application user to write good parallel algorithms in-order to extract performance of large-scale applications and libraries on Multi-Core processor platforms and computing systems with GPGPU Accelerators. By understanding the PEMG-2010 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, and GPGPUs / GPU Computing.

The **PEMG-2010** workshop proceedings covers current trends in Multi-Core processors, performance enhancement through software multi-threading, performance analysis tools, keynote address talks from academic institutes and from IT company sponsors (AMD, Intel, HP, NVIDIA) on Multi-Core Processors, GPU computing – CUDA enabled NVIDIA GPUs, GPGPU- AMD-ATI Stream computing SDK, application perspective. Special sessions have been arranged to demonstrate performance analysis tools on Multi-Core Processors, Intel Threading Building Blocks (TBB), GPU computing-CUDA, GPGPU- AMD-STI Stream Computing SDK and Hybrid (Heterogeneous) Computing based on OpenCL mixed programming. The **PEMG-2010** workshop participants will get an opportunity to use several Multi-Core Processors (Multi Socket and Multi-Core processors). The laboratory sessions effectively address the performance and usability challenges with a suite of tools that participants found useful in measuring, understanding, and improving the performance of their parallel programs during the hands-on session.

The **PEMG-2010** workshop is organized in two modes in which participants can attend 4-day programme (Both Mode-1 & Mode-2) or exclusively Mode-2 programme. 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. This workshop will give insights into performance aspects of

sequential /parallel programs using different programming paradigms. Participants will use Intel & AMD Multi-Core systems, Cluster of Multi-Core processors, GPGPUs, and GPU Computing systems. The 3<sup>rd</sup> and 4<sup>th</sup> day of this workshop will cover an overview of GPU Computing, CUDA enabled NVIDIA, GPGPUs- AMD-ATI Stream Computing SDK, Heterogeneous computing - OpenCL, and Hands-on session.

**Mode-1 (Day 1-2):** The sessions include six classroom lectures on Multi-Core processors and Software Multithreading. Two keynote lectures on emerging topics of Multi-Core processors from application perspectives will be covered. Second half of each day, participants will get expose to Programming using OpenMP, Pthreads, f90, MPI-2.0, use of Tuning & Performance Visualization tools, **Intel** Threading Building Blocks, performance issues on Multi-Core processors. The day-1, and day-2, hands-on sessions of **PEMG-2010** workshop introduce the participants to the fundamentals of parallel programming on Multi-Core processors by letting the participant to write simple parallel programs that executes on Multi-Core processors. Also, participants will be exposed to the practical aspects of classroom lectures in the hands-on session.

**Mode-2 (Day 3-4):** The 3<sup>rd</sup> and 4<sup>th</sup> is focus on current and future emerging parallel processing platforms and Programming Paradigms such as CUDA enabled NVIDIA, GPGPU-Stream Computing SDK, Heterogeneous Computing, GPU programming based on OpenGL & OpenCL Programming and Hybrid Computing based on mixed programming. During this sessions, participants will get an overview of evolving GPU Computing, Heterogeneous Computing, Hybrid Computing based on mixed programming for HPC applications. On Second half of each day, participants will get an opportunity to walk-through some of the programs specifically designed for this workshop. Software IT Private Sectors deliver keynote talks on GPGUs/ GPU CUDA enabled NVIDIA GPUs, AMD-ATI - Stream Computing SDKs, & OpenCL Programming. Experts from Private Sector demonstrate programming based on GPUs on 3<sup>rd</sup> and 4<sup>th</sup> day of **PEMG-2010** workshop.

C-DAC views the **PEMG-2010** 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 and 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.