Performance Analysis of Industrial CFD software Using Parallel Measurements produced on Silicon Graphics x86-64 Compute Hardware

By

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Abstract

Significant upgrades in the x86-64 processor (s) roadmap have been released during the past two years. For industrial CFD these were rapid changes in their compute environments over a relatively short time period [3], [4] and [6]. Such changes were reflected in various hardware and software aspects such as number of sockets/cores on a die, FSB speed, memory speed and other architectural features such as interconnect fabrics, I/O sub-systems and communications software. M. Kremenetsky et al [1] examined the performance of the CFD application Fluent in compute environments using Intel's x8664 Harpertown and Nehalem processors, partially covering the latter processor due to its unavailability at that time within large parallel configurations. In this paper we will extend this work to analyze the parallel performance of a number of industrial CFD applications from the perspective of the Nehalem processor design (e.g. sockets, cores, memory controller and QuickPath interconnect) and its main features of Hyper-Threading Technology and Turbo mode [3]. In particular we select the SGI Altix ICE 8200EX architecture with Intel's Nehalem processor as the underlying compute platform [8]. Also considered are factors influencing parallel scalability and the effects of compute cluster interconnect features. The CFD applications considered are ANSYS CFX, FLUENT, STAR-CCM+, STAR-CD, POWERFLOW, CFD++ and OpenFOAM. For each CFD application, we examine and compare the benefits of the Nehalem features of Hyper-threading and Turbo mode. The objective is to also identify through experiments of this paper the circumstances that are likely to impair an application from benefiting from these features. Furthermore the analysis in this paper, being a collective performance analysis of several Industrial CFD applications, may be viewed as an introduction to future papers targeting applications individually in more detail taking into account solvers choice, communication software, type of flows and physical properties.

1.0 Introduction

The past two years has seen significant changes in the x86-64 processors roadmap. Both Intel and AMD have released a significant number of such products. The former had this roadmap marked mostly by Woodcrest, Clovertown, Harpertown, Wolfdale and lately Nehalem. On the other hand AMD had an equivalent roadmap starting with Barcelona and recently with Shanghai. In the light of CFD applications this represented a relatively rapid change in computational environments. Such changes were reflected in various hardware and software aspects, e.g number of sockets/cores on the die, FSB speed, memory speed and other architectural features such as Infiniband, Gige, I/O sub-systems and communication software, e.g MPI message passing libraries. Previously the authors M. Kremenetsky et al [1] have examined the effects of Intel hardware in the light industrial CFD applications, specifically FLUENT, covering mostly x86-64 parallel compute hardware based on Intel's Harpertown and Nehalem. The latter was partially covered as it was not widely available in large compute configurations at that time. In this paper we wish to analyze the parallel performance of a number of industrial CFD applications by focusing on recent compute environments. For such environments we have chosen those from SGI very recent products, namely SGI Altix ICE 8200EX based on Intel's Nehalem processor. The reasons for this choice are two fold, one is that such a product provides a rich and complete compute environment, e.g. compute nodes, communications hardware and I/O sub-system. Furthermore the authors [1] have based their work on SGI platforms thus this choice provides a smooth continuity when examining and analyzing parallel performance. The main focus will be on analyzing the parallel performance of CFD applications from the perspective of the Intel's Nehalem design and features [3], for example sockets and cores on the Nehalem die, number of compute nodes, message passing software and communications medium. In addition we wish to examine the benefits of the Nehalem feature of Hyper-threading Technology. Hyper-threading Technology is an Intel-proprietary technology [2] used to improve parallelization of computations where a processor with hyper-threading enabled is treated by the operating system as two virtual processors. The other Nehalem feature we wish to examine is that of Turbo mode. In turbo mode the processor monitors the activities of its cores and accordingly boosts the clock speed of some cores when the remaining cores are idle or less than fully utilized. For the CFD software we have used examples from ANSYS CFX, FLUENT, STAR-CCM+, STAR-CD, POWERFLOW, CFD++ and OpenFOAM as well known industrial CFD applications.

Section 2, presents a brief hardware background for the Nehalem processor architecture and the SGI Altix ICE 8200EX. In section 3, we introduce single-node performance numbers for a number of CFD applications based on standard benchmarks chosen by their developers. This will lead to a comparison between Nehalem performance versus its predecessor Harpertown [4]. Section 4, presents parallel measurements obtained from running a number of CFD applications on the SGI x86-64 Altix ICE 8200EX compute hardware. In section 5, we discuss factors influencing applications parallel scalability and the effects of compute cluster Infiniband interconnect features. In sections 6 and 7 we describe the Hyper-threading Technology and Turbo mode Nehalem features and their