SUPRENUM: Architecture and Applications*

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1 Introduction

In the last decade the numerical simulation of physical or chemical processes has gained increasing importance in many fields of science and engineering. Computer experiments, as the numerical simulations are often called, offer the advantage that they are free of principal limitations, whereas experiments are either not always accurate (e.g. wind tunnel) or even not possible (e.g. reentrant space vehicles, astrophysics, elementary particle physics, etc.).

Numerical simulations have become possible with the advent of supercomputers. Their computational power allowed much more complex simulations and their use reduced experimental time and costs considerably.

Computer experiments, however, still require much more computational power for instance in the field of aerodynamical simulations: The present generation of supercomputers allows either simulations of complex flow patterns on simple geometries (e.g. large eddy simulations) or simplified and less accurate models on complex geometrical structures (e.g. Euler equations around airplanes) but not both simultaneously. In order to increase the applicability and accuracy of CFD simulations, faster supercomputers – necessarily based on multiprocessor architectures – are required.

Of course, the present limitations are not only due to lacking computer performance. Also new mathematical models (e.g. for turbulent flow) are necessary as well as new numerical algorithms. What is really needed in the future is the combination of fast numerical methods (like multigrid) with advanced high-performance computer architectures. All attempts to achieve only one of these goals and to neglect the other one have failed. The speed-up of numerical software in the last years has been considerably larger than the speed-up gained by vectorcomputers and any machine which does not optimally support the fastest numerical methods is not really useful.

This central challenge gave rise to the German SUPRENUM project which aimed at the development of a parallel supercomputer for numerical applications. SUPRENUM was developed as a joint project of 14 institutions (universities, research laboratories, industrial companies) and was successfully completed with the SUPRENUM 1 computer. This machine was presented to the public at the Hanover fair in April 1989.

The SUPRENUM architecture has been published many times (see [9], [10], [2], [3]). It can be characterized as a distributed memory multiprocessor system with a medium granularity with

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a powerful vector processor in each single node. Hence it combines the advantages of the cost effective SIMD vector processing in each node with the performance capabilities and flexibilty of an MIMD system.

This paper presents the essential features of SUPRENUM. After a short discussion of the basic architectural principals, the hardware is briefly sketched and the software concept as well as some of the most important applications are outlined.