

Università di Ferrara

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VLDG - Computational Physics Group (Department of Physics)

The Department of Physics of the University of Ferrara is active in several research areas in physics and applied physics. It is also the home of the courses in physics offered (at the undergraduate and graduate level) by the University of Ferrara and also has a strong involvement with the courses in Computer Science.

The department is a member of the hArtes project with its research group in Computational Physics and the VLDG (VLSI and Logic Design Group).

The Computational Physics group

The Computational Physics group has been working since about ten years in the study of several complex physical system, using numerical techniques, most notably Monte Carlo based simulations.

The main areas of interest for the group are:

- Lattice Gauge Theories (LGT), that is Monte Carlo study of the discretized version of Quantum Chromodynamics (QCD), the theoretical model of the interactions between quarks, the constituents of (a class of) elementary particles.
- Computational fluid dynamics. The group has worked mainly on the statistical properties of convective turbulence in fluids, with a focus on theoretical analysis.
- Statistical mechanics. Main interests in this area are associated to the properties of the phase transitions of complex spin systems, such as spin-glasses.

The group has developed over the year a deep know-how not only on the use of high-performance computing (HPC) for scientific applications, but also on the development of application-specific highly-optimized compute engines able to satisfy our ever increasing computing requirements within affordable budget limits.

In this area, the group has played a crucial role in:

- the development of several generations of the APE massively parallel computer, optimized for LGT applications.
- APE (Array Processor Experiment) is an international collaboration with INFN (Italy), DESY (Germany) and the Université Paris-Sud 11 (France). The most recent APE generation (code-named apeNEXT) has been in stable operation since the end of the year 2005. A central apeNEXT site (in Rome) hosts a massive system with approximately 5000 processors, delivering a peak performance of about 10 Tflops. Note that APE, admittedly a research machine, is de facto the only large scale computer entirely developed in Italy.
- the development of the FPGA-based IANUS processor, in collaboration with the Università di Roma (La Sapienza) and BIFI (Instituto de Biocomputación y Física de Sistemas Complejos) in Zaragoza (Spain).
- IANUS is a large scale configurable system, based on latest generation FPGAs, optimized for the simulation of spin system. A large scale IANUS installation is being assembled. It will be ready late in 2007. The system, containing 256 FPGA-based processing nodes, delivers, for the specific application for which it has been optimized, the same computing power as approximately 25000 high-end PCs.

LEFT: the APENext system installed in Rome; RIGHT: one board of the Ianus system.

The VLDG

The VLDG is part of the Department of Physics of the University of Ferrara. It shares people with the Computational Physics group, and its main focus is on VLSI design and hardware implementation, having its roots in the development of several generations of the high-performance APE computing system.

This group is the bridge between the architectural computer developments made in response to computational requirements in the area of simulation physics and their exploitation in other areas.

Over the years, the VLDG has collaborated with several partners, such as:

- Atmel Roma, on architectural and VLSI aspects of the design of the Diopsis family of DSP processors.
- Thales Alenia Spazio, on the design of dedicated computing architectures for the scheduling of data packets for the

next generation of telecommunication satellites.

- ASI, with which a collaboration is considered for the design of a computer architecture optimized for low power for space applications.

During the last five years, our area of interest has included:

- High-Performance systems design and implementation (APEnext)
- Special-Purpose computing (Ianus)
- VLSI design (with special interests on Associative Memories, Floating Point operators and Register Files)

The VLDG is deeply involved in the hArtes project.

Within the project, the group has a key role in the design and test of the hArtes Hardware Platform (hHp), a reconfigurable parallel system, based on several tightly connected computing cores, that will be used as the main computational workhorse for the applications developed by the project.

AMchip03: an Associative Memory chip developed (in collaboration with INFN-Sezione di Pisa) for the CDF experiment at Fermilab (Batavia, IL - USA).

Home page of the APE project: <http://apegate.roma1.infn.it/APE/>

Home page of the Ianus project: <http://df.unife.it/ianus/>

Home page of the Computational Physics group (in Italian): <http://df.unife.it/fisicacomputazionale/>