# PI CV

Massimo Bernaschi (MB) graduated in Physics *summa cum laude* at Tor Vergata University – Rome in 1987 under the guide of Prof. Giorgio Parisi. After that, he continued his collaboration, as contractor, with INFN (Istituto Nazionale di Fisica Nucleare) for the APE project, i.e., for the realization of a parallel computer with SIMD architecture specialized for the simulation of quantum chromo-dynamics. His main contribution was the development of the parallel version of Montecarlo techniques for lattice gauge theories. Moreover he contributed to the development and debugging of the APE system software.

**Systems Programming**

In the end of 1987 IBM employed MB in the Scientific Research branch in Rome. There he cooperated in the development of the Electronic Vocabulary of the Italian Language. In 1988 MB worked at the IBM lab of Palo Alto (US) on PAIX, the parallel version of AIX/370, a UNIX operating system for mainframes. He identified and developed the changes and enhancements required to the AIX/370 scheduler and dispatcher. He was invited to deliver a seminar on that subject at the "Computer Science" Department of the Berkeley University (one of the two major UNIX temples) in October 1988. Back in Rome, he joined the IBM European Center for Scientific and Engineering Computing (ECSEC). In 1989 he started performance assessment tests for systems based on the new POWER/PowerPC architecture, running the AIX operating system, working very closely with the IBM development labs in the US. Between 1990 and 1993 he belonged to an international IBM team appointed to assess different technologies (FDDI, HiPPI, Fiber Channel) available at that time for high-speed connections among workstations. In 1990 MB implemented the first TCP/IP connection between IBM Italy and the IBM Research Laboratory of Yorktown (USA) by "encapsulating" the IP traffic in a SNA link. In 1995, he started to work on special purpose real time operating systems.

In the beginning of 1998 he joined the Institute for Applied Computing (IAC), part of the National Research Council (CNR) of Italy as Director of Technology. There he designed and implemented extensions to the Linux operating system so as to alleviate one of the most recurring security problems (buffer overflow in privileged programs) avoiding to the source code of existing applications. The resulting software (named Remus) has been made available from http://remus.sourceforge.net. He also developed a solution for the migration of TCP connections and SSL sessions between Linux systems. Also this software (named SockMi) is available from http://sockmi.sourceforge.net. Since 2004 he has been working on heterogeneous wireless networks (e.g., 802.11 e GSM/UMTS). In particular, he designed and led the implementation of an efficient mechanism for vertical handover in such networks that has been successfully tested both at transport and application level (VoIP). MB designed and implemented, starting on 2007, the first open source implementation of the CAPWAP protocol. CAPWAP is a standard, interoperable protocol that enables an Access Controller to manage a collection of Wireless Termination Points. This software is available from http://capwap.sourceforge.net.

Since 2001, he has been an adviser of the Italian Police and Carabinieri for computer related crimes. He has been also an ICT security auditor for the United Nations.

Since 2012 he has been designing and implementing solutions for indexing and searching large scale heterogeneous textual data and for collecting and indexing data from the Dark Web (ToR network), within the context of two EU projects that MB led as PI. The indexing technology, based on HPC techniques and in-memory stream processing is more than four times faster with respect to previous solutions based on the Apache *Spark* general engine for Big Data processing.

**Parallel Computing and Cooperative Processing**

In 1989, MB started the development of COOPLIB. COOPLIB is a middleware that optimizes the use of cooperative processing with minimal changes in existing applications.

COOPLIB can be especially used for the interactive control of numerical applications ("computational steering"). Through a graphical interface it is possible to: i)retrieve, in real time, data available on remote systems, record results and handle them through rewind and playback functions; ii)modify parameters and, thus, the simulation behavior ; iii)suspend the execution and preserve the state of the system.

The COOPLIB package has been used both by the scientific (Cornell University, ETH Zurich) and industrial (Piaggio) community.

Since 1990 MB has been studying parallel computing. His main contributions have been:

Creation of a FORTRAN library and a pre-processor that can run parallel applications on distributed systems by using a virtual shared memory prototype developed by the IBM Research Division and a macro-tasking model with explicit synchronization. In order to finalize this project, MB spent an overall period of 6 months at the IBM "T. J. Watson" research lab in Yorktown.

Design and development of a completely new version of the PVM distributed computing package that was then included in the IBM SP2 product offer of parallel systems called PVMe. The main new characteristics of PVMe were: i)an original mechanism to manage the memory dynamically and avoiding fragmentation without resorting to expensive garbage collection techniques; ii)the development of "quasi-optimal" algorithms (based on LogP and postal theoretical models) for collective communications (those involving more than two tasks). Thanks to a simple generalization, such algorithms showed much better performance versus the classic approach based on a binomial spanning tree; iii) the minimization of interactions with the operating system. The organizations that used PVMe included, among others, Cornell University, the European Space Agency, CRS4 (Cagliari), CINECA (Bologna), CASPUR (Rome), the National Center for Atmospheric Research (Boulder, Colorado), the oil company Shell. PVMe was used in the EUROPORT project financed by the European Community to support the industrial use of parallel computing. The validity of "quasi-optimal" algorithms for group communication was proved not only for PVMe but also for MPI, the de-facto standard for parallel programming in distributed memory systems. MB was directly involved in several projects for the parallelization of industrial and scientific codes. He worked at the parallel version of the "Car-Parrinello" method for studying molecular dynamics ab-initio. Major companies like BMW and Opel/GM have used codes like FIRE or PAMCRASH that he parallelized.

Starting on 2006, he developed, with a grant offered by the School of Engineering and Applied Sciences of the Harvard University, MUPHY (MUlti PHYsics), a modern parallel code that combines molecular dynamics and the Lattice Boltzmann method for the simulation of complex bio-fluidics phenomena like translocation of bio-polymers through nanopores, hemodynamics or cell crowding. With MUPHY, MB has been among the finalists at the Gordon Bell Challenge, the most important award in the supercomputing field, in 2010, 2011 and 2013 (he received the honorable mention in 2011). MB has been finalist in the GB Challenge also in 2015 with a different code that simulated blood and cancer cell separation in complex microfluidic channels.

In 2008 MB started to employ Graphics Processing Units (GPU) as a platform for high performance simulations in several application fields. He has been a pioneer in multi-GPU programming. He designed algorithms and implemented them in CUDA for the study of large-scale graphs, for crypto analysis, for signal processing, for soft-matter phenomena (foams, emulsions, *etc.),* for numerical linear algebra. For his results, Nvidia named him CUDA Fellow in 2012 (MB has been first in receiving that qualification in Europe).

**Simulation of complex systems**

MB always continued his activity in statistical mechanics, stochastic methods, and optimization problems. In particular, he worked on phase transitions of spin systems.

Such activity enabled MB to gain extensive experience in the application of numerical techniques for the analysis and interpretation of data. On such a basis, in 1999 he started working on a project sponsored by INA, a that time one of the major Italia Insurance Companies, for the study of financial time series related to the "fixed income" market.

Currently, MB manages a project with the Italian Ministry of Economy whose aim is to develop a decision support tool for the optimal issuance of public debt securities. As a result, he developed and now maintains the SAPE (Sistema Analisi Portafogli Emissione) software.

In 1996 he started working on the optimization and parallelization of simulation programs for the Immune System. In 2003 MB started to collaborate with the "L. Spallanzani" Hospital in Rome to the application of the ImmSim simulator to the study of the HIV infection and other diseases.

In 1998 he coordinated and participated in the development of a simulation code for chemical-physical phenomena within catalytic converters. The technique employed (based on digital physics concepts) enabled to avoid the round-off problems due to floating point arithmetic.

**Teaching and Reviewing**

Since 1999 he has been teaching, as Adjunct Professor, Systems Programming to Computer Science students at "Sapienza" University (Rome).

In the 2014-2017 A.Y.s, he taught a class in "Multi and Many Core Programming" at "Tor Vergata" University (Rome).

He teaches Digital Forensics in the Master in Systems and Network Security at "Sapienza" University. In the past he taught Computational Finance for the Master in Computational Finance and Risk Management at Modena University.

MB has been adviser of 10 PhD candidates.

Since 2006 he is an expert and reviewer of scientific projects funded by the European Commission within the VI, VII and H2020 Framework Programs.