Newsletter Interview

NEXT GENERATION EU: THE ITALIAN NATIONAL CENTRE FOR SUPERCOMPUTING IS BORN

Interview with Antonio Zoccoli, president of INFN and new president of ICSC Foundation - Italian Research Center on High Performance Computing, Big Data and Quantum Computing



The governing bodies of the ICSC Foundation*, which will manage one of the five National Centres established by Italy's National Recovery and Resilience Plan (PNRR) were installed on 19 July. Thus, the National Research Center in High Performance Computing, Big Data and Quantum Computing was born. The centre was proposed by INFN and 51 founding members distributed throughout the country, coming from the public and private sectors, from the

world of scientific research and industry. The new National Centre will be based at Tecnopolo in Bologna, an innovation hub promoted by the Emilia-Romagna Region, in part thanks to investment from the Italian Government and European Union. The hub already hosts the Data Center of the European Centre for Medium-Range Weather Forecasts (ECMWF) and will shortly welcome the Leonardo supercomputer managed by CINECA and by INFN Computing Centre. The project will create a network and system of specific expertise, competences, and resources of firms that operate throughout Italy in many fields. The aim is to build a distributed, cross-organisation infrastructure that supports scientific research and the production world in innovating and digitalising the country.

To complete its mission, ICSC will count on EU Next Generation funds, as part of the PNRR's Education and Research Mission coordinated by the Ministry of University and Research (MUR), of € 319,938,979.26 of which 41% will be invested in the south. In particular, of the overall funding, more than € 100 million will be dedicated to staff, an investment that is considered a priority, with female participation of at least 40%, and with almost € 16 million reserved for PhD scholarships and, thus, youth higher training and careers. ICSC, in line with the PNRR's strategic goals, will implement its specific goals by promoting the careers of young people and initiatives for overcoming the gender gap in professional careers and the gap between the north and south of the country. During the first plenary assembly, which was hosted in the Emilia Romagna Region's headquarters, the founding members of ICSC elected Antonio Zoccoli, INFN president, to the presidency of the Foundation, and the ten members of the Board of Directors**. We asked Antonio Zoccoli, newly elected president of the ICSC Foundation to tell us about the project.

INFN was the promoter of the proposal for the national centre for supercomputing. The proposal was evaluated and then selected by MUR to be implemented within the context of the PNRR. How did we achieve this positive outcome?

The big science experiments, from those in high-energy physics to those in astroparticle physics, are characterised by the production of big data, i.e. large quantities of data that must be stored, shared, and analysed. Working in the main big science projects globally has, therefore, enabled INFN to develop, over time, long and consolidated experience in terms of managing data and the necessary infrastructure to do so. I'll give one example of many: at the start of the 2000s, the particle physics community engaged in the big experiments at CERN's LHC accelerator, which produce enormous quantities of data, created a global infrastructure called "Grid" that enabled researchers to best employ all the computing resources available. Created in the context of fundamental physics research, the Grid was, thus, the precursor to the commercial cloud that, today, we all have available on our phones. INFN is the only Italian institution that can boast similar experience in managing big data and, thanks to its expertise and to those of the other fifty partners in the project in various other sectors, it was possible to develop a well-structured, solid and concrete proposal that was evaluated positively and, therefore, approved by the MUR, under whose aegis the five national centres established in the PNRR were created.

Let's start by explaining what high-performance computing, big data, and quantum computing mean.

High-performance computing (HPC) is a technology that makes it possible to perform high-performance calculations, i.e. to do parallel calculations that make it possible to speed up and strengthen operations. Let's take, for example, the case where we're studying the behaviour of the atmosphere. What we do is divide the atmosphere into many small volumes to understand how the various parameters evolve, such as the temperature or humidity, in each one of these. Between these little volumes, information is continuously exchanged, for example, the temperature of volume A influences the temperature of volume B. Therefore, to study their evolution, the temperature of each individual volume must be placed in correlation with the others: the calculation, then, needs to be made in parallel, so that the information is exchanged contemporaneously. Thus, the parallel calculation implies having many CPUs, many processors, that perform calculations simultaneously and exchange information in real time. Parallel calculation is useful for solving certain types of problems, for example in fluid dynamics, for studying the atmosphere or climate, but also for training algorithms of an emerging discipline: artificial intelligence. On the other hand, it isn't necessary if I need to process a big sequence of data, such as those produced in the LHC experiments, where you analyse event by event. In this case, we use the so-called "high-throughput computing" (HTC). HTC is the technology required for analysing great guantities of data, so-called big data, i.e. guantities of data greater than the petabyte (one million gigabyte). HPC and HTC are, therefore, two different computing technologies that are useful for resolving different problems and the best national experts in HPC and HTC are part of this project, with CINECA and INFN being the two leading institutions in Italy in these two sectors.

Finally, there is a potential future computing technology, based on a new concept: the contemporaneous presence of different states. This is quantum computing. In the case of a conventional computer, one bit may be zero or one, while in a quantum computer, one bit may be zero, or one, or zero and one at the same time: it's the qubit, the quantum bit. This way we can have more information. Machines that are based on quantum bits

make it possible to have great power with just a few qubits. It is a very promising technology; in any case, it is not yet sufficiently developed to provide a service. The difficulty lies in keeping the so-called quantum coherence, in managing the quantum states, microscopic states at the atomic level, which are very sensitive to outside interference. System stability is needed; for this reason, quantum computers are typically cryogenic machines. It is a completely different technology from that of ordinary computers. The challenge will be, then, to build a stable, powerful quantum computer with a sufficiently high number of qubits, and then create the software capable of best employing it.

In which sectors and how will the supercomputing centre operate?

The new centre will gather the top-class Italian scientific communities together in ten different areas; it will be built on two structural columns of equal significance: infrastructure and the thematic areas and it will be organised according to the Hub and Spoke model. The hub will be responsible for validating and managing the research programmes, whose activities will be led by the Spokes and by the firms and their affiliates, including through tenders open to research institutions and companies outside the centre.

There will be ten Spokes and they will take care of as many thematic areas: Future HPC & Big Data, Fundamental Research & Space Economy, Astrophysics & Cosmos Observations, Earth & Climate, Environment & Natural Disaster, Multiscale Modelling & Engineering Applications, Materials & Molecular Sciences, In-Silico Medicine & Omics Data, Digital Society & Smart Cities, Quantum Computing. The Future HPC & Big Data and Quantum Computing Spokes will be technological and will have as their frontier goal the development of advanced chips and microchips and emerging technologies like those of quantum computing.

In addition, the centre will be able to support the other four National Centres funded as part of the PNRR. In addition to the National Centre for HPC, Big Data and Quantum Computing, there are: the National Research Centre for Agricultural Technologies, the Sustainable Mobility Center, the National Biodiversity Future Center, and the National Center for Gene Therapy and Drugs based on RNA Technology. It is envisaged that the five centres will work synergistically where possible. Our Centre could host the data of the other National Centres. This is not something envisaged by the project, but it could be stipulated by specific agreements, such as, for example, already happens with the National Centre dedicated to medicine that will lean on us for managing its data. On the other hand, the other National Centres also find correspondence with some of our thematic areas.

What will be INFN's role within this project?

INFN promoted and coordinated the project proposal. After its approval, the ICSC Foundation was set up, which will have the task of activating it and of which INFN is a member together with another fifty firms coming both from the world of scientific research and the business world. During the first meeting of members, the president and the board of directors were appointed, who will be guarantors that the project is implemented according to the design proposed. INFN, having elected the president of the Foundation, will have, in a certain sense, a guiding role, but it will also have an executive one, because it has appointments in some of the thematic areas where the foundation will develop. In particular, INFN will contribute to the infrastructure area, in the context of which, resources dedicated to big data and to the cloud interface, with which all the infrastructure will be managed, will be strengthened. In addition, it will work on some thematic areas: such as fundamental research, an area where it carries out its mission, but also that of medicine, a sector where INFN

has expertise in managing images and developing models and algorithms for analysing medical data, and that of quantum computing. If in ten years the next computing machine is a hybrid machine, thus also quantum, it will be important to have acquired all the necessary skills to be able to best employ it.

What will the first goals of the Centre be?

We will take the first steps in September, when we build the Centre in both organisational and administrative terms, clearly defining all the development plans and allocation of resources. Thus, we will proceed in parallel with the creation of the infrastructure, which will require at least a couple of years, but will probably continue for all three years of the start-up phase of the project, and with the development of applications that will be useful for employing the infrastructure. These will be developed by the most competent people in the country in specific areas, and they may be used both in the field of research and in the industrial system. The research activity that the centre will undertake will, thus, be software development: the Centre does not need to do scientific research, it needs to develop the infrastructure and its applications, thanks to which research will be done; it will build tools for scientific research.

What will be the impact of the centre nationally and internationally and in which sectors?

If we manage to successfully conduct this ambitious project, Italy will be the first country equipped with national computing infrastructure of the "data lake" variety, which means a fast data transmission network, cloud access to this network, and infrastructure throughout the country that, thanks to the cloud, will be assigned dynamically and virtually. This will enable the most effective use of the resources available throughout the country. The users will no longer use a physical computer to store their data and a physical CPU to analyse them but will be provided with virtual machines that will be assigned based on their availability so as to maximise the efficiency of the process. This means flexibility and optimisation of resources, which thus become almost unlimited. The implementation of this project would produce a unique example internationally. Succeeding in this endeavour would mean providing the country with infrastructure at the cutting-edge in Europe, rather, in the world, I think. We will be the first to thoroughly complete this exercise: today, in fact, many countries have several centres spread throughout their territory, which, however, are not coordinated among them - rather, they're often competing. We want, instead, to systematise all the national resources. In this context, the role of private businesses is also important. In the next few years - and, in reality, this is already happening - all the scientific disciplines will produce an unprecedented quantity of data. Where will these data reside? How will they be analysed? And how will they be used? This is a hot topic for scientific research, but of great interest to industry as well: from monitoring plants to the development of new materials, from the impact of the climate on precision agriculture, to transport. It is, therefore, essential that industry develops the skills to efficiently and effectively use the computing infrastructure. Hence the strong involvement of companies.

The project is, then, ambitious and could make Italy an attractive hub and reference point in Europe.

Definitely. So much so that Europe is investing in it. The powerful, pre-exascale machine that CINECA will bring to the Centre is supported with funding not just from Italy but Europe too. And the quantum machine too, with which we'll equip the National Centre, will be co-funded with European funds.

In addition, we will also be attractive to the world of research and business. In fact, 32 million in open calls are planned, i.e. calls for funding projects in which those who are not already part of the Centre will be able to be involved - both public and private parties. Another 32 million will be available for Centre members with the aim of promoting innovation, increasing the TRL (Technology Readiness Level, i.e. the degree of technological maturity) of new products to finalise the process, to let them complete the so-called last mile until their entry in the market.

Let's talk about the staff who will operate the Centre: how will they be recruited? What opportunities will there be in terms of young people's and women's careers, which "Next Generation EU" wishes to support?

The centre will rely on senior staff coming from Foundation partners: we can rely on more than 1,500 high skill professionals who will dedicate part of their working time to the project. But we are targeting young people, their involvement is a priority: both the universities and the research bodies involved in the centre will advertise doctoral scholarships (200 in total) and post-doc grants (another 200) for various roles. And at least 40% of the people who will work on the project will be women: we are studying initiatives to implement to incentivise their participation, so as to reach the goals of "Next Generation EU". Among these goals, there are also some investments in the South, for 41% of the funds: we are planning to strengthen the network that already exists and construct new centres. The centre, for example, of the CMCC (Euro-Mediterranean Center on Climate Change) foundation in Lecce will be strengthened, and new centres will be built in Frascati, Gran Sasso, and Naples, where a parallel calculation centre will be founded and managed by CINECA. The CINECA computing centre and INFN Tier1, both in Bologna, will also be strengthened. In addition, the whole GARR (Group for Harmonisation of Research Networks) network, the Italian network for transmitting data for research, which currently operates between 10 and 100 gigabyte per second, will be strengthened. It is, then, already a very fast network, but what we would like to do is to make it even faster and more high performing: we want to bring it to multiples of terabit per second, thus speeding it up by a factor of 100 compared to now, or even a thousand. This would make it possible to really implement extraordinary performance. These are some of the goals of our ambitious but absolutely realistic project.

* The ICSC foundation: INFN (the Italian Institute for Nuclear Physics), CINECA, GARR (the Group for Harmonisation of Research Networks), CNR (the National Research Council), INAF (the Italian National Institute for Astrophysics), INGV (the National Institute for Geophysics and Volcanology), IIT (the Italian Institute of Technology), CMCC, FBK (the Bruno Kessler Foundation), ENEA (the National Agency for New Technologies, Energy and Sustainable Economic Development), CRS4 (the Centre for Advanced Studies, Research and Development in Sardinia), OGS (the National Institute of Oceanography and Applied Geophysics), the University of Bologna, the University of Ferrara, the University of Bari, Milan Bicocca University, Sapienza University of Rome, Tor Vergata University of Rome, University of Trieste, University of Padua, University of Pavia, University of Trento, University of Turin, University of L'Aquila, University of Naples Federico II, University of Pisa, University of Florence, University of Catania, University of Calabria, University of Salento, University of Modena and Reggio Emilia, University of Parma, Polytechnic University of Bari, Polytechnic University of Milan, Turin Polytechnic, SNS (Scuola Normale Superiore of Pisa), SISSA (International School for Advanced Studies), Autostrade per l'Italia Group, Engineering Ingegneria Informatica, Eni, Ferrovie dello Stato Italiane, Fincantieri, Foundation for Urban Innovations, Humanitas Research Hospital, IFAB (International Foundation Big Data and Artificial Intelligence for Human Development), Intesa Sanpaolo, Leonardo, Sogei, Thales Alenia Space Italy, Terna, UnipolSai Assicurazioni.

**Members of the newly elected board of directors: Emilio Fortunato Campana of the CNR, Paolo Maria Mancarella of the University of Pisa, Francesco Scarcello of the University of Calabria, Donatella Sciuto of the Polytechnic University of Milan, Simona Tondelli of the University of Bologna, Francesco Ubertini of CINECA, Matteo Laterza of UnipolSai, Elisabetta Oliveri of Autostrade per l'Italia, Andrea Quacivi of Sogei, and Francesca Zarri of Eni.