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How to fit ten million computers into a single Supercomputer? – The ExaNeSt project paves the way.
European consortium becomes the trailblazer in the development of the most challenging architectures in next-generation computing.

Heraklion, Crete, Greece and Sheffield, Yorks, UK

The next generation of supercomputers must be capable of a billion billion calculations per second. These are referred to as Exascale computers and with this ability to undertake such volume of calculations, they will transform our understanding of the world through advanced simulation and problem solving.

It will take ten million processors working together to achieve Exascale – the equivalent of asking ten million individuals to solve, *in a single second*, a problem that would normally take one person 3 months (about ten million seconds); so how can this be achieved?

A step towards the Exascale vision is being made by a European Consortium, funded by the Horizon2020 initiative of the EU and entitled *ExaNeSt*, which is building its first straw man prototype this year, 2016.

The Consortium consists of twelve partners, each of which has expertise in a core technology needed for innovation to reach Exascale. ExaNeSt takes the sensible, integrated approach of co-designing the hardware and software, enabling the prototype to run real-life evaluations, facilitating its scalability and maturity into this decade and beyond.

Being able to move, process and manage unprecedented volumes of data would allow greater insight into many areas of our lives including climate change, cosmology, drug design, energy safety, national security, material science, medicine and countless other scientific and engineering disciplines.

Understanding more of the world allows us to manage its future more effectively and contribute positively to the advancement of society. Current technology, however, is faced with many technical limitations in reaching an Exascale architecture. Key barriers are energy and cooling demands, compact packaging, permanent storage, interconnection, resilience and not least application behavior.

ExaNeSt addresses these using: energy-efficient ARM cores, quiet and power-efficient liquid cooling, non-volatile (e.g. flash) memories integrated into the processor fabric, and the development of innovative, fast interconnects that avoid congestion.

Manolis Katevenis, Head of Computer Architecture at **FORTH-ICS**, said: "As project coordinators, we will seek an efficient collaboration of all partners to build the prototypes – as we have done time and again in the past – because only through real, working systems can computing advance to its next stage."

Peter Hopton, Founder and CVO of **Iceotope Ltd**, commented: "Iceotope can uniquely enable the ExaNeSt project due to its 3D cooling capability - and by doing so, the Iceotope platform lends itself readily to the first, demonstrable Exascale prototype."

Allinea are providing the ARMv8 profiling and debugging tools which David Lecomber, CEO of Allinea Software added "will ensure that developers of key scientific software packages are able to exploit the potential of the system."

Likewise, Stefano Cozzini, founder and co-CEO of **eXact-lab** remarked that "eXact-lab has key expertise in developing and porting scientific packages suited to Exascale, especially those in the fields of earth and material science."

The competences of **Enginsoft** range from mechanical and structural engineering to optimization in fields such as fluid dynamics, electromagnetism, multi-physics and more. Gino Perna, Head of ICT and HPC at Enginsoft commented that "it is this simulation expertise which is most effective for innovation on this architectural scale".

"**MonetDB** Solutions brings the knowledge of more than 3 decades of database research and industrial practices to the consortium," stated Martin Kersten, Co-founder and CEO of MonetDB Solutions. "Through its open-source columnar database system MonetDB, MonetDB Solutions will showcase the applicability of the ExaNeSt platform for a broad scope of extremely compute intensive Business Intelligence and Big Data Analytics applications."

Feeding huge amounts of data efficiently in an architecture of Exascale proportions will be enabled through the core expertise of **Fraunhofer ITWM.** Bernd Lietzow of Fraunhofer noted that "Within the framework of the project, Fraunhofer ITWM contributes to the focus area of developing a highly scalable I/O approach based on Fraunhofer's parallel file system BeeGFS as a core component."

Daniel Raho, R&D Director of **Virtual Open Systems**, said: "Thanks to ExaNeSt, Virtual Open Systems will push High Performance Computing (HPC) specific virtualization technology to the Exascale level, to enable users and maintainers to cope with the unprecedented size of the system."

Giuliano Taffoni, the project principal investigator at **INAF**, commented:
"INAF's astrophysical codes will contribute to the design and testing of the network and storage infrastructure. In turn, access to ExaNest prototype resources will offer a unique opportunity for computational cosmology to execute complex simulations of our Universe with unprecedented resolution."

In terms of building high speed interconnects for the immensity of Exascale platforms, Piero Vicini, leader of the **INFN** team, said: "The ExaNeSt prototype will allow us to explore and

validate innovative architectural solutions required to speed-up the execution of our large-scale scientific applications which includes a simplified model of human brain function."

A broad range of expertise in the design of communication infrastructure is also being supplied by the **University of Manchester.** Javier Navaridas, Lecturer at the University of Manchester said: "Computing systems of the magnitude confronted by ExaNeSt feature highly challenging communication demands which cannot be complied with using current off-the-self technologies, therefore we will use our core expertise to produce an efficient, high performance communication infrastructure."

Javier Marti, Director of NTC, and Julio Sahuquillo, member of the GAP research group, commented: "**UPV** will explore and analyse the proper state-to-date photonic and optical link technologies at different levels of the Exascale platform."

ExaNeSt collaborates with other European R&D projects and partners, including:

- **EuroServer,** which developed the underlying efficient communication between ARM processors;
- **ExaNoDe,** which focuses on ARM based microserver HPC computer design;
- **ECOSCALE,** which develops programmable-hardware accelerators for specialized computations;
- **Kaleao Ltd.**, which enables and produces new generation computing platforms by converging compute, storage, and networking into efficient, extremely compact, and transparent server solutions.
- **Xilinx Inc.**, providing FPGA technology and flexible high speed communication.
- **Micron Inc.,** for advanced low power memory and storage technology.

With the core technologies of its partners and collaborators, ExaNeSt is anticipated to complete its first straw man prototype in 2016, a full prototype in 2018, and will inevitably leave a trail of innovation in its path.
Visit: http://www.exanest.eu

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About FORTH: FORTH is a world renowned research centre in Greece, it provides, through its Institute of Computer Science, expertise in interconnection networks, storage systems software, and prototyping.
Visit http://www.ics.forth.gr/carv

About Iceotope: Iceotope provides reliable, energy efficient liquid cooling solutions for electronics to deliver a sustainable environment.
Visit http://www.iceotope.com

About Allinea: Allinea is the leading developer of scalable development and performance analysis tools for high performance computing. Its tools are used on 80% of the world's largest supercomputers and enable scientists, researchers and engineers in research and industry to achieve better results from HPC clusters quickly and efficiently.
Visit http://www.allinea.com

About EnginSoft: EnginSoft is an Italy-based multinational consulting company, which is active in the field of Simulation-Based Engineering and Sciences (SBES).
Visit http://www.enginsoft.com

About ExactLabs: ExactLabs is an innovative start-up in the area of HPC providing advanced services for scientific computation and data management.
Visit http://www.exact-lab.it

About MonetDB Solutions: MonetDB Solutions is the technical consulting company for the open-source column-based database system MonetDB, specialised in database technologies for Business Intelligence and Big Data Analytics. In MonetDB Solutions, world-leading database researchers and engineers support software companies in developing leading edge applications addressing vertical markets, e.g., telecom, health care and education.
Visit http://www.monetdbsolutions.com

About Fraunhofer: The Fraunhofer Institute for Industrial Mathematics (ITWM) in Kaiserslautern, Germany, focuses on mathematical approaches to practical challenges like optimisation and visualisation.
Visit http://www.itwm.fraunhofer.de/en

About Virtual Open Systems: Virtual Open Systems is a France-based high-tech company active in virtualization and embedded software development. The areas of expertise through open source software development include networking and accelerators virtualization, automotive virtualized systems, security and QoS for embedded systems.
Visit: http://www.virtualopensystems.com

About INAF: INAF is the leading Italian research institute in astronomy and Astrophysics. INAF contributes to network and storage design thanks to its HPC application. INAF coordinates application related activities.
Visit: http://www.inaf.it

About INFN: INFN is one of the most influential and prestigious scientific institutions in the world, mainly engaged in research on Sub Nuclear Physics and related instruments and technologies. INFN has close collaboration with Universities along with international and national scientific institutions.
Visit: http://www.infn.it

About University of Manchester: The University of Manchester is one of the UK's top research-led universities, the APT group is well known for its million-core SpiNNaker system. The group is also working across a range of Exascale challenges and provides this consortium with wide expertise across interconnects, large-scale systems, HPC and data analytic applications and system manufacturing.
Visit: http://www.manchester.ac.uk

About UPV: UPV-GAP provides strong expertise in interconnection networks and will deliver photonic solutions for the final ExaNeSt system.
Visit: http://www.ntc.upv.es/index.html and http://www.gap.upv.es