Project N°: 610456

D1.6 Second Public Activity Report

March 6, 2017

Abstract:

This deliverable includes a summary of the EUROSERVER project objectives and progress up to the end of the project.

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The EUROSERVER Consortium consists of the following partners:

Participant no.	Participant names	short name	Country
1	Commissariat à l'énergie atomique et aux 2nergies alternatives	CEA	France
2	STMicroelectronics Grenoble 2 SAS	STGNB 2 SAS	France
3	STMicroelectronics Crolles 2 SAS	STM CROLLES	France
4	STMicroelectronics S.A	STMICROELECTRONICS	France
5	ARM Limited	ARM	United Kingdom
~~6~~	~~Eurotech SPA~~	~~EUROTECH~~	~~Italy~~
7	Technische Universitaet Dresden	TUD	Germany
8	Barcelona Supercomputing Center	BSC	Spain
9	Foundation for Research and Technology Hellas	FORTH	Greece
10	Chalmers Tekniska Hoegskola AB	CHALMERS	Sweden
11	ONAPP Limited	ONAPP LiMITED	Gibraltar
12	NEAT SRL	NEAT	Italy

Revision history

Version	Author	Notes
0.1	Isabelle Dor	Creation
0.2	Denis Dutoit	Review

Content

Publishable summary

EUROSERVER develops a micro-server solution for today's cloud infrastructure that is tailored for their workloads (see [1]). The EUROSERVER platform combines several architectural key features, such as: highly efficient ARMv8 processors, an innovative scalable memory scheme called UNIMEM and the use of Hybrid Memory Cubes to maximize density and bandwidth of external memory. It takes advantage of the most recent integration technologies including FD-SOI and organic System-in- Package for energy efficiency. It uses advanced software features to optimize resource sharing and communication within the system (see [2]).
Its architecture is actually designed for scalability. Therefore, its basic building block, i.e. a micro-server board, is also suitable for use in smaller packaging for embedded applications such as transportation, or telecom infrastructure.
This holistic approach puts EUROSERVER in a leadership position in several technical areas. Thus, the members of the consortium contribute actively in both software and hardware scientific communities in computer architecture, system software, integration technology, software virtualization and network infrastructure.

EUROSERVER has started in September 2013 and completed at the end of January 2017.

Very rapidly a systematic requirement analysis was conducted and used to refine the system specifications for a set of three distinct scenarios (Cloud/Enterprise, Embedded and Communications).

A first prototype was developed in the early phase of the project, based on discrete components and programmable devices. Memory sharing was demonstrated using this platform, as well as particular Linux kernel modules and hypervisor extensions.

Then several strategic choices were made thus consolidated EUROSERVER architecture. An innovative structure based on interconnected compute "coherent island" was adopted for an optimal balance between data locality and transfer efficiency. The compute SoC internal structure was organized around several independent "chiplets" implementing the islands. The coupling between these chiplets was realized by high speed serial links. Physically, the system was integrated onto a cost effective organic interposer solution. Besides, the consortium had selected the Hybrid Memory Cubes (HMC) technology for its central memory: this technology increases the density by stacking DDRAM modules in order to offer better bandwidth and memory storage density that are directly connected to the cores. Two prototype platforms were thus created; a Juno R2 development board based system and a Trenz development platform. Both have energy-efficient, quad-core ARM 64-bit Cortex A53 processors, with the Juno differing in that it is also a big.LITTLE design and has a Cortex-A72.
The Trenz 0808-based, UltraScale+ system, Figure 1, combines a Trenz module with 4xA53 cores with a placeholder for a System-in-Package (SiP) 32-core A53. Presently the 32-core SiP is not ready but could be included in one of the follow-up projects that has resulted from EUROSERVER including ExaNeSt, ExaNoDe and EcoScale.

These hardware innovations would not be exploitable without software support. Software developments have been carried out in specific areas demonstrating that hardware agnostic improvements can be made for micro-servers in general. To differentiate EUROSERVER from micro-server and typical server designs the key software technologies being worked on are:

- Shared memory scheme UNIMEM that allows coherent islands implemented on multiple boards to share memory regions between them, allowing for better provisioning strategies and allow for greater-in-memory workloads than are possible with current best-of-breed

solutions. Memory from each board is divided into a local and a remotely addressable region. UNIMEM technology is a licensed IP technology and has been investigated by a number of companies and research organisations.

- The MicroVisor, a new hypervisor technology that derives from Xen. It is purpose made for low-power, energy efficient platforms such as ARM that have many, albeit weaker cores. Traditional hypervisors are now quite "bloated" and require a large amount of resources that is not available to ARM-based boards. Instead a lighter, more efficient platform has been developed that natively works with ARM and Intel architectures. The overhead for workloads running in Virtual Machine in near negligible.

These innovations are being demonstrated with applications across the data center and telecommunication domain. A number of relevant workloads have been evaluated including web-server hosting (LAMP/WAMP), distributed databases (HADOOP) and network-communications (C-RAN).

EUROSERVER outcomes are promoted through press releases released via partners' communication team, [3], HiPEAC communication network and HiPEAC newsletters (HIPEAC INFO n°49 and 50, see [4] for HiPEAC INFO n°49, the article for HiPEAC INFO 50 being in progress currently). The November press release ([5]) was been picked up by the media and some websites, such as http://www.electronicspecifier.com/around-the-industry/more-computations-for-less-energy.
A dissemination video was produced, targeting at a large audience and highlighting EUROSERVER key achievements, available at https://youtu.be/2EnEKoZ2Tp0.

EUROSERVER being technically challenging offers a great opportunity for junior engineers and PhD students to contribute to the project while working on highly specific subjects directly connected to EUROSERVER (see [6], [7]). There are presently 19 PhD thesis and masters in progress among the academic EUROSERVER partners on different challenging topics such as HMC, virtualization, etc. It actively participates to EUROSERVER findings dissemination together with the consortium partners' involvement in scientific conferences in the field of computer architecture, information technology, embedded computing, etc., presenting the most recent technological developments. Since the beginning of the project, EUROSERVER findings have been presented in more than 70 conferences and workshops.

Several on-going H2020 projects in the area of "HPC Core Technologies" - e.g. GREETINGS16 (CATRENE), 2.5D Integration with an Active Interposer (including I/O) with ExaNoDe, Virtualisation + runtime Apps with ExaNoDe and ExaNeSt, Intereconnects + Storage with ExaNeSt, GPU accelerator + advanced processing with ExaNoDe and FPGA Accelerators in the ECOSCALE project, Mont Blanc-3 - are aligned with EUROSERVER approach and could benefit from EUROSERVER technology. The final EUROSERVER platform (Figure 2) combining a pair of UltraScale+ boards on a backplane that provides electrical and physical connectivity will be used in the several follow-up projects that include EcoScale, ExaNoDe and ExaNeSt to form the basis of a European Server.

The emerging key differentiator for EUROSERVER is improved resource utilisation (see [2]). Just as Cloud computing and virtualisation enables companies to converge workloads from many distributed and under-utilised hardware platforms into smaller numbers of servers, EUROSERVER proposes to more efficiently exploit micro-server and low power hardware in order to pave the way towards the next generation of more power efficient servers.

The project has led to the development of two spin-off companies; KALEAO Ltd. that is headquatered in Cambridge, UK (see [8]) with labs in Crete (see [9]) and Italy, and ZeroPoint Technologies that

came out of Chalmers, Sweden (see [10]). KALEAO has introduced a unique new generation of web-scale, true-converged server appliance that features physicalized resource sharing. OpenStack virtualization services and extreme core density, leading to low energy consumption and significant computing capabilities. ZeroPoint commercializes the memory compression innovations.

From all these dissemination facts, EUROSERVER provides a European foundation and ecosystem for scalable, low-power and low-cost approach for computing.

Figure 1: The EUROSERVER designed, NEAT produced, prototype board. Not shown are a Trenz 0808 module and a SIP

Figure 2: A pair of EUROSERVER boards, assembled onto a backplane with electrical connectivity, designed by EUROSERVER and produced by NEAT

References

[1] EEtimes article, "Microservers Brew in Europe's Labs", C. Kachris, October 16, 2014 - http://www.eetimes.com/author.asp?section_id=36&doc_id=1324294

[2] EEtimes article, "*European server project promotes ARM on FDSOI*", P. Clarke, January 02, 2015 - http://www.electronics-eetimes.com/en/european-server-project-promotes-arm-on-fdsoi.html?cmp_id=7&news_id=222923411&page=0

[3] Kaleao & FORTH Press release, "*Crete becomes the Silicon Island of high technology research and development*"

[4] Press release, HiPEAC INFO n°49, "*EUROSERVER: transferring and using power efficiency know-how*", January 2017

[5] Press release, "*More computation for less energy – the European way*", November 3, 2016 - https://www.hipeac.net/press/6797/euroserver-more-computations-for-less-energy-the-european-way/

[6] Y. Durand and al, "*EUROSERVER: Energy Efficient Node for European Micro-servers*", DSD 2014 proceedings, August 2014, Verona, Italy.

[7] M. Marazakis and al., "EUROSERVER: Share-Anything Scale-Out Mucri-server Design", Date 2016 proceedings, March 2016, Dresden, Germany.

[8] Silicon Angle article, "UK-based hyper-convergence startup bets on ARM processors", P. Gillin - October 3, 2016, http://siliconangle.com/blog/2016/10/03/u-k-based-hyper-convergence-startup-bets-on-arm-processors/

[9] HPC article, "KALEAO and FORTH Announce New Development Centre", June 23, 2016 - https://www.hpcwire.com/off-the-wire/kaleao-forth-announce-creation-new-development-centre/

[10] EEtimes article, "*Memory compressor IP can save time, energy*", P. Clark, January 19, 2017 - http://www.analog-eetimes.com/news/memory-compressor-ip-can-save-time-energy

Texts of the communication releases [3], [4] and [5] are available in Annexe 1.

ANNEXE 1: Communication releases

[3] Press release, "Crete becomes the Silicon island for high technology research and development", June 2016

PRESS RELEASE

Crete becomes the Silicon-Island of high technology research and development

The technology excellence of FORTH grows as a key European research centre and attracts a growing hub of high-tech corporate development

21 June 2016

FORTH – Foundation for Research and Technology - Hellas, in Heraklion, Greece and KALEAO Ltd. – High Tech company based in Cambridge, UK – announced today the creation of the KALEAO's Heraklion development centre that officially seals their on-going collaboration towards a joint research lab on low power computing and shows a clear indication of the growing international high-tech involvement in Crete, Greece. The centre is going to be inaugurated on the 30th of June in Heraklion.

FORTH is one of the largest research centers in Greece with modern facilities, highly qualified personnel, and a reputation as a top-level research foundation worldwide.

KALEAO designs and manufactures advanced computer systems and delivers solutions based on its innovative approach to web-scale computing.

Commenting on these new developments, Manolis Katevenis, Head of the CARV Laboratory and Deputy Director of the Institute of Computer Science (ICS) of FORTH, said: "We are proud of the 33-year history of FORTH and ICS, as well as of the CARV Laboratory and the numerous hardware and software prototypes that we have built here. We are very happy with our collaboration with KALEAO, a really innovative company on the leading edge of modern high technology, and we look forward to jointly making many more innovations. I feel that we now have an R&D environment in Crete which is at the forefront of worldwide high technology, and I invite all interested computer scientists and engineers in hardware design and in systems software to contact us, with the prospect of becoming part of this growing environment."

To the declaration of FORTH, Professor John Goodacre, co-founder and CSO of KALEAO, added: "We are very happy with our development centre in Crete and with our collaboration with FORTH, since these yielded the design of key components of our flagship solution KMAX. With the increasing research agenda of the CARV Laboratory at FORTH and the new KALEAO development centre in the Science and Technology Park of Crete (STEP-C), we expect to see an increasing collaboration between FORTH and industry, collaboration that creates new exciting academic and job opportunities in silicon high-technology in this beautiful Greek island – The new ``Silicon-Island''.

FORTH started collaborating with the founders of KALEAO in *EuroServer, a* research project part of the European Union's FP7 programme. *EuroServer* focuses on the innovation and implementation of new computer system solutions to enable the power efficient delivery and scalability of computing for the server market.

One of the goals of *EuroServer* is to research and innovate key components towards ARM-based micro-servers. FORTH, as a partner of the project, designed various hardware prototypes of key

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PRESS RELEASE

importance for the project, including significant operating system software components. These systems leverage ARM based processors to obtain very high energy efficiency, in line with the growing requirement of low power IT infrastructure coming from the industry.

"The largest problem with data centres, today, is their growing consumption of electricity" – added Professor Manolis Katevenis – "It is estimated that if the data centres of USA alone were a country, that country would be listed 12th in the world in electricity consumption, somewhere between Italy and Spain".

To reduce their energy consumption, data centres must build their servers using new platform approaches and more energy-efficient components. KALEAO leverages ARM based technologies in a platform capable of delivering unprecedented computing capabilities to the data centre and IT infrastructure in terms of energy efficiency, density, agility, and IT simplification.

Last week, KALEAO unveiled KMAX, their new commercial product, offering a true converged rack mountable hardware platform and software computing appliance. The low-power ARM-based KMAX is capable of offering 192 eight-core servers with 48 solid-state disk (SSD) slots within just 3U height of rack space.

"Today's data centres are made of hundreds to tens of thousands of server computers and form the back-bone of Information and Communication Technology" – commented Professor John Goodacre – "The KALEAO KMAX solution provides a true converged platform with appliance-level simplicity, to reduce the total cost of ownership while delivering a rich catalogue of services, including content on the web, databases, social networks, telephony, on-line transactions, and smart storage".

FORTH is a founding partner of *HiPEAC*, the European Network on High Performance and Embedded Architecture and Compilation, which coordinates European research in these areas; KALEAO is also a member of that same network. FORTH's technological innovation continues through participation in a group of three European Horizon2020-funded projects that further develop this technology approach, *ExaNeSt*, *ExaNoDe*, and *ECOSCALE*.

For more information:

- www.kaleao.com
- www.ics.forth.gr

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[4] Press release, HiPEAC newsletter – HiPEAC INFO n°49, "EUROSERVER: transferring and using power efficiency know-how", January 2017

Technology transfer

EUROSERVER: transferring and using power efficiency know-how

MORE COMPUTATIONS FOR LESS ENERGY

The EU-funded project EUROSERVER has developed a new approach for ARM-based technology to halve the cost of powering data centres. Based on the concept of chiplets, where multiple silicon subsystems are mounted in an integrated device, along with an associated new groundbreaking system architecture, the project has enabled more energy-efficient servers and has even inspired startups motivated by the new technology.

Delivering the potential to reduce energy consumption in data centres by at least half, the breakthrough leads to substantial reduction in the total cost of acquisition and operation (total cost of ownership (TCO)).

EUROSERVER created system architecture and runtime software innovations: the sharing of peripheral devices, access to system wide memory, compression of data to better utilize memory and lightweight hypervisor capabilities. These are being demonstrated with applications across the data center and telecommunications domain. All reduce energy consumption and have been developed for systems built around energy-efficient 64-bit ARM®v8-based architecture.

Two startups have already been launched, inspired by the technology created during the project:
KALEAO Ltd., with headquarters in the UK and labs in Crete and Italy, has introduced a unique new generation of web-scale, true-converged server appliance that features physicalized resource sharing, OpenStack virtualization services and extreme core density, leading to low energy consumption and significant computing capabilities.

ZeroPoint, in Sweden, commercializes the memory compression innovations.

Data centres account for a huge consumption of power. If all the data centres in the USA alone were a country, their energy consumption would rank 12th in the world. As the capacity and number of data centres increase, so do the financial and environmental impacts of their vast energy use. EUROSERVER's innovation will take efficient and scalable ARM processors and use the flexibility of a System-on-Chip (SoC) design at the system level to create a new type of server.

This evolution is comparable to the transition from mainframe computers to mass-produced personal computers (PCs) in the 1980s, which in turn evolved into modern servers. With smartphones the contemporary equivalent of 1980s PCs, now is the time to take advantage of their architectural flexibility and evolve them to create the energy-efficient servers of the future.

GREEN COMPUTING NODE FOR EUROPEAN MICRO-SERVERS

At the time of writing, the consortium is in the final stages of results evaluation that will be released in the project workshop at the HiPEAC 2017 Conference in Stockholm (25 January 2017). These results compare Intel XeonD, ARM Juno, Gigabyte MP30AR0 ARM X-Gene1 and the EUROSERVER prototype platforms.

The the EUROSERVER platform is based on a Xilinx UltraScale+ FPGA that demonstrates novel technologies built in the project. A number of relevant workloads are being evaluated including web-server hosting (LAMP/WAMP), distributed databases (HADOOP) and network communications (C-RAN).
ARM based processors currently dominate the mobile market and EUROSERVER is attempting to integrate the full stack as a power-efficient alternative to the Intel-based designs that currently dominate the data centre.

Please find the most up-to-date set of results on the EUROSERVER webpage.

EUROSERVER has received funding from the European Union's FP7 programme under grant agreement no.610456. For more information, visit www.euroserver-project.eu or contact Ms. Isabelle Dor - isabelle.dor@cea.fr
About KALEAO: visit www.kaleao.com
About ZeroPoint: visit www.zptcorp.com

[5] Press release, "More computation for less energy – the European way", November 2016

More computations for less energy – the European way

New approach for ARM-based technology to halve the cost of powering data centers

Grenoble, 3 November 2016 – Press Release

EUROSERVER, a leading EU-funded research project, is paving the way toward lower energy consumption in data centers. Based on the concept of chiplets, where multiple silicon subsystems are mounted in an integrated device, along with an associated new groundbreaking system architecture, the project has enabled more energy-efficient servers and has even inspired startups motivated by the new technology.

Delivering the potential to reduce energy consumption in data centers by at least half, the breakthrough leads to substantial reduction in the total cost of acquisition and operation (total cost of ownership (TCO)).

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Isabelle Dor, Research Engineer at CEA and EUROSERVER Coordinator, said: "EUROSERVER is delivering vital energy savings for data centers and CEA/LETI is proud to coordinate this important EU-funded project. The SoC architectures and advanced packaging solutions being developed bring us one step closer to scalability and power efficiency in data centers. We are also delighted that two startups have been created to leverage innovations from the project."

"ARM is committed to enabling energy-efficient computing. Together, the consortium helped define a set of Reliability, Availability and Serviceability (RAS) requirements for enterprise servers," said John Goodacre, director of technology and systems, *ARM*. "ARM subsequently enhanced its processor architecture with the ARMv8.2-A release, which included a specific extension in support of RAS."

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"This ambitious European project has benefited from ST's expertise in complex SoC architectures and ARM-core integration, along with silicon technology and packaging techniques," said Patrick Blouet, Collaborative R&D programs manager, STMicroelectronics.

Simone Cabasino, President in *NEAT*, noted: "We are happy to design, develop and bring-up the board and the system for the project, and we are also proud to be a technology partner of the KALEAO startup."

Julian Chesterfield, Director of the Emerging Technology Group at *OnApp* Ltd. reports: "The EUROSERVER design highlights the trend for power efficient and high density computing environments entering the data center. As a cloud infrastructure provider, our customers will benefit from the improvements in the virtualization platform, being able to handle more end-users while at the same time benefiting from lower electricity costs."

Giampietro Tecchiolli, CEO of *KALEAO* Ltd., stated: "We started KALEAO with the goal to revolutionize the server market by enabling true convergence at web-scale with our KMAX products. EUROSERVER has been a source of partnerships, inspiration, expertise and technology contributions. In sharing many of the EUROSERVER paradigms, we use ARM cores in order to reduce the costs and energy for a server while achieving unprecedented compute density."

Per Stenström, Professor at *Chalmers University of Technology*, Sweden, said: "This project gave us the opportunity to develop novel memory optimizations, including memory compression and hybrid memory management technologies, for servers and high-performance platforms."

Then, as founder and CTO of *ZeroPoint* Technologies AB, Per Stenström added: "Our results at Chalmers in EUROSERVER are so promising that we created this spin-off company with the mission to commercialize these memory compression technologies; we are very happy with the interest that we have already seen among several potential customers."

Manolis Katevenis, Head of the Computer Architecture Lab at *FORTH/ICS*, said: "The new UNIMEM architecture, to which we made key contributions, allows communicated data to enter directly into receiver memory, thus reducing overhead. We are glad to have built prototypes and systems software for UNIMEM, and to have supported KALEAO through their Development Center in the Science and Technology Park of Crete."

Emil Matus, Senior Researcher at *TUD, the Dresden University of Technology*, noted: "TUD aims to advance the software defined mobile network infrastructure by exploiting the EUROSERVER high density computing architecture for 5G radio access dataflow applications. This project allowed us to develop the dataflow framework with dynamic resource management capability, enabling the exploration and efficient deployment of Cloud-RAN wireless algorithms."

Paul Carpenter, Senior Researcher at *BSC*, the Barcelona Supercomputing Center, added: "BSC is advancing the state of the art in energy-efficient systems and runtime software to support memory capacity sharing, energy-efficient scheduling of tasks and workloads and energy-aware virtual machine placement in cloud infrastructure."

About EUROSERVER: this project is funded by the European Union, under FP7 Grant Agreement 610456. For more information, visit www.euroserver-project.eu or contact Ms. Isabelle Dor - isabelle.dor@cea.fr

About KALEAO: visit www.kaleao.com

About ZeroPoint: visit www.zptcorp.com

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