EcoCloud

EPFL

EcoCloud

CONTENTS

WELCOME
TO ECOCLOUD

Welcome to EcoCloud, an academic centre unique of its kind, promoting research and development of hardware and software computing technologies as key enablers for a sustainable future.

Our mission revolves around design and management of cloud computing to achieve effective services with minimal environmental impact. Our projects include, but are not limited to, digital twins for smart cities, sustainable artificial intelligence technologies, and energy-aware scientific computing. We are also working towards the definition and creation of a new circular economy of large IT infrastructures and datacentres to minimize carbon footprint and long-term environmental damage.

Our strategy is to create and grow a community around EPFL and its key industrial players to support environmentally sustainable information technology. Our ambitions and success rely on synergy, collaboration and support by private industry. With our strong emphasis on industry teamwork and technology transfer, the Industry Affiliates Program (IAP) aims to build long-term partnerships founded on research collaborations, large-scale University-Industry partnered research grants and PhD student dissemination activities with industry, internships, and fellows.

Overall, the EcoCloud centre aims to be a landmark in digital transformation for a sustainable society.

EcoCloud

THE CENTER
AND ITS FACILITIES

On October 1st, 2024, Prof. Giovanni De Micheli took over the direction of the EcoCloud Centre from Prof. David Atienza.

"Historically, EcoCloud's main focus has been to deliver technologies jointly with top companies in the information technologies (IT) sector to help them optimize the large cloud computing infrastructure of public cloud systems," says David Atienza, Associate Vice President for Centers at EPFL.

IT infrastructure as enabler for a sustainable society

"In collaboration with the School of Engineering (STI), the School of Computer and Communication Sciences (IC), the School of Architecture, Civil and Environmental Engineering (ENAC), and the School of Basic Sciences (SB) we are exploring key research areas in information technology," says De Micheli.

Four multi-center discussions, and multiple projects kicked off in recent years, in the following research areas: energy-constrained and sustainable deep learning — in collaboration with the AI Center and the Center for Imaging; computational and data storage sustainability for scientific computing — in collaboration with the eSpace Center and the Energy Center, sustainable smart cities and transportation systems — in partnership with the FUSTIC Association; AI Center and CLIMACT Center, and energy-constrained trustworthy systems, including Bitcoin technology in collaboration with the Center for Digital Trust. Most recently, the SwissChips project has burst onto the scene in a bid to boost the Swiss chip manufacturing industry (*see page 14*) — in a collaboration between EPFL, ETHZ and CSEM.

In addition to its multi-center research projects on specific applications, EcoCloud is also working on fundamental technologies to enable sustainable IT infrastructures, such as minimal-energy computing and storage platforms, or approaches to maximize the use of renewable energy in data centers and IT services deployment.

Moreover, EcoCloud will keep developing and strengthening, in this new era of sustainable cloud computing research, its collaboration of many years with IT partners through its Industrial Affiliates Program (IAP), such as Hewlett Packard, Intel, IBM, Huawei and Oracle, who have confirmed their interest in continuing to collaborate with the center on its new research topics.

THE CENTER
AND ITS FACILITIES

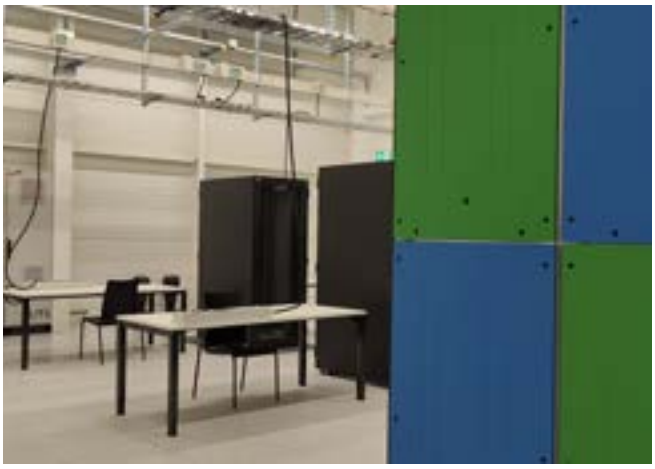
A new research facility for sustainable computing

"We have assembled an experimental facility dedicated to multi-disciplinary research on sustainable computing at EPFL," says Atienza (see page 16). In this facility, EcoCloud provides a detailed IT monitoring infrastructure (e.g., performance, power, energy, temperature, etc.), supported by specialized IT personnel, to assist and support the EPFL laboratories in performing tests related to multi-center IT research projects and cloud infrastructures. Work on UrbanTwin and HeatingBits is underway, SEAMS (a collaboration between the Embedded Systems Lab, EcoCloud, SCITAS and a number of French partners, interacting with SKACH) also started in early 2024.

"This year, research activities are focussed on the agreed projects with the different schools and centers at EPFL, but in the future, we expect to make open calls for anyone at EPFL interested in research related to sustainable computing to be supported by EcoCloud."

Best practices for IT infrastructure

The dissemination of best practices for sustainable IT infrastructure is another core mission of EcoCloud. "In



Inside the CCT Datacenter

cooperation with the Vice-Presidency for Academic Affairs (VPA), we are going to develop a course about the fundamentals of sustainable computing for EPFL students at the master level, which will be offered by the Section of Electrical Engineering (SEL) and the Section of Computer Science (SIN) for the complete campus," says Atienza.

"Continuous education for professionals is also important. We plan to offer training to companies to support and assist them in their digitalization processes and help them understand how to implement the most sustainable IT technologies and processes possible.

"IT is the engine of our digital world. With a compound annual growth rate of more than 16 %, cloud computing must embrace a strategy of digital responsibility to support economic progress and societal development without compromising the future of our planet," concludes Atienza.

The key pillars of EcoCloud activity

<< IT infrastructure as enabler for a sustainable society

- Energy-constrained and sustainable deep learning
- Sustainable smart cities and transportation systems
- Computational and data storage sustainability
- Energy-constrained trustworthy systems

<< Sustainable IT infrastructure

- Minimal-energy computing and storage cloud platforms
- Sustainable use of renewable energy in IT infrastructures

<< Dissemination of best practices for IT infrastructure in a sustainable society

<< Preparation of courses and focused programs on sustainable computing, for IT professionals

<< Annual EcoCloud event on sustainable computing trends and forward-looking research

Research Facility Experts

Dr. Xavier Ouvrard
Systems Specialist

Dr. Miguel Peón-Quirós
Research Scientist

FACULTY MEMBERS
AND LABS - IN ALPHABETICAL ORDER

Anastasia Ailamaki

Data-Intensive Applications and Systems Laboratory

Enabling discoveries in scientific domains through automating physical database design, revolutionizing exploration algorithms in very large data repositories

Alexandre Alahi

Visual Intelligence for Transportation

Socially aware AI applying computer vision, deep learning and human-robot interaction to transportation applications

David Atienza

Embedded Systems Laboratory

Efficient machine-learning based resource management in servers and data centers. Low-power design of edge AI and heterogeneous server architectures

Antoine Bosselut

Natural Language Processing Lab

Natural language processing, machine learning, artificial intelligence

Thomas Bourgeat

Verification and Computer Architecture Laboratory

We leverage the power of formal methods and high-level hardware programming languages to ensure the correctness and the security of tomorrow's computers

Maria Brbic

Machine Learning for Biomedicine Lab

Developing machine learning methods that solve real-world data challenges, paving the way for new biomedical discoveries

Edouard Bugnion

Data Center Systems Laboratory

Data center efficiency, infrastructure support in network and data planes for OLDI applications. System security, Trusted Execution Environments in hardware

Andreas Burg

Telecommunications Circuits Laboratory

Design of technology systems, prototypes and demonstrators for the development of robust, reliable and energy efficient systems

Volkan Cevher

Laboratory for Information and Inference Systems

Robust machine learning and optimization, reinforcement learning, game theory, and deep learning

Drazen Dujic

Power Electronics Laboratory

Ensuring reliable, compact, and efficient power electronics-based power supplies for data centers. From the power grid to the chip

Babak Falsafi

Parallel Systems Architecture Laboratory

Computer architecture, vertically integrated data center systems, post-Moore server design

Olga Fink

Intelligent Maintenance and Operations Systems Laboratory

Development of intelligent algorithms for complex infrastructures and industrial systems. Deep learning and hybrid algorithms for intelligent maintenance systems

FACULTY MEMBERS
AND LABS

Pascal Frossard

Signal Processing Laboratory

Computer vision, medical imaging, network machine learning, robust machine learning, deep learning

Rachid Guerraoui

Distributed Computing Lab

Distributed machine learning with Byzantine resilience and privacy. Distributed algorithms for new technologies: RDMA and NVRAM

Paolo Ienne

Processor Architecture Laboratory

Computer and processor architecture, FPGAs and reconfigurable computing, electronic design automation, computer arithmetic

Martin Jaggi

Machine Learning and Optimization Laboratory

Machine learning, optimization algorithms and text understanding, as well as several application domains

Colin Jones

Automatic Control Laboratory

Theory and practice of optimization-based, or model predictive control with a particular emphasis on problems arising from renewable energy challenges

Sanidhya Kashyap

Robust Scalable Systems Software Lab

Robust and high-performance software for heterogeneous hardware: concurrency, scheduling, networks, analytics and fuzzing

Anne-Marie Kermarrec

Scalable Computing Systems Laboratory

Large-scale distributed systems, failure resilience, performance and privacy-preservation, frugal distributed learning systems

Jean-Paul Kneib

Laboratory of Astrophysics

Reliable transport and precise integration of a flow of 707 Petabytes per year of data from large arrays of radiotelescopes

Christoph Koch

Data Analysis Theory and Applications Laboratory

Efficient and scalable massively parallel real-time analytics engines, complex expressive declarative and domain-specific languages in databases

Viktor Kuncak

Lab for Automated Reasoning and Analysis

Precise automated reasoning techniques: tools, algorithms and languages, for the construction of reliable computer systems

Zhengmao Lu

Energy Transport Advances Laboratory

Towards a deeper understanding of phase change phenomena, creating sustainable energy and water technologies by optimizing interfacial transport

Gabriele Manoli

Laboratory of Urban and Environmental Systems

Analysis and conceptualization of complex urban and environmental dynamics, to guide the design of greener and more sustainable territories

FACULTY MEMBERS
AND LABS

François Maréchal

Industrial Process and Energy Systems Engineering

Process and energy system engineering for efficient use and reuse of energy, efficient energy conversion, integration of renewables and complex system integration

Elison Matioli

POWERlab

Microchannel liquid cooling of data center components, ultra-efficient purpose-built cooling solutions

Giovanni De Micheli

Laboratory of Integrated Systems

Modelling of hardware with dedicated languages, co-design of software and hardware, system-level optimization with efficient performance, energy consumption and yield

Christophe Moser

Laboratory of Applied Photonics Devices

Non-linear transformation in fiber optics to simplify machine learning tasks

Martin Odersky

Programming Methods Laboratory

The design and implementation of Scala, to achieve a fusion of object-oriented and functional programming, compatible with platforms such as Java and .NET

Mario Paolone

Distributed Electrical Systems Laboratory

Developing smart grid concept solutions to efficiently deliver sustainable, economic and secure electricity supply

Mathias Payer

HexHive Laboratory

Software testing to discover security bugs. Sanitization for memory, type, and API violations. Fuzzing of complex code to trigger bugs

Clément Pit-Claudel

Systems and Formalisms Lab

Can we leverage compilers, languages, and proofs to build more robust, more efficient, and more trustworthy systems?

Demetri Psaltis

Optics Laboratory

Optical systems such as spatiotemporal nonlinearities in multimode optical fibers, used as neuromorphic neural networks

Jürg Schiffmann

Laboratory for Applied Mechanical Design

Design and experimental investigation of small scale turbomachinery for decentralized energy conversion

Mirjana Stojilovic

Parallel Systems Architecture Laboratory

Electronic design automation, reconfigurable computing, electromagnetic-compatibility and signal-integrity issues, hardware security

Carmela Troncoso

SPRING Lab

Designing strong, embedded security and privacy guarantees in complex systems. Quantification of the information an adversary can infer from acquired data

Amir Zamir

Visual Intelligence and Learning Lab

The development of computer vision models that can function as part of larger intelligent systems

INDUSTRY AFFILIATES
MISSION

The EcoCloud Industry Affiliate Program (IAP) offers companies a unique opportunity to collaborate with EPFL faculty, students and researchers. Affiliates are given unparalleled access to new technologies and ideas as they move from laboratory to marketplace. The ideal platform for communication and discovery between the research and corporate communities, the program catalyzes collaborative research, customizes educational programs and facilitates graduate recruiting.

The EcoCloud IAP was created to enable connections and strengthen collaborations between EcoCloud and industry. While there are numerous benefits to joining the IAP and becoming an affiliate, the advantages boil down to three key reasons:

<< To gain early awareness of the latest research - Through meetings, visits and online resources, EcoCloud Industry Affiliates get to preview the latest research findings from across our labs before they are published.

<< To explore potential research collaborations and sponsorships - Companies can get much more by sponsoring EcoCloud research directly. Becoming an affiliate allows you to see how we work and what we do, giving you the insights you need to identify research partnerships.

<< To recruit EcoCloud students - Our students are one of our most valuable assets. They can add substantial value to your company as interns or employees. We post student profiles on the members-only website, and you can meet them at our Annual Event. EcoCloud can also host talks geared towards students, and distribute job and internship announcements.

INDUSTRY AFFILIATES
MEMBER BENEFITS

The EcoCloud IAP is a corporate membership program whereby companies pay an annual membership fee in return for facilitated access to the research programs, the researchers and the graduate students, offering the ability to capitalize on the unique, dynamic trans-disciplinary innovation culture at EPFL. At the heart of EcoCloud's IAP activities are entrepreneurial startups emerging from our research, the delivery customizable executive education, industry collaboration and technology transfer.

Specific benefits of becoming an Affiliate include:

<< Annual Event - An annual conference exclusively designed for our existing and prospective Industry Affiliates and research colleagues to showcase the activities of the center. The event's program includes activities such as presentations by EcoCloud faculty and researchers on the latest research results organized around chosen research themes; student poster sessions; lab tours; demonstrations; discussions on grand challenges, applications and technology roadmaps; and opportunities to meet and network with EcoCloud researchers, students and colleagues.

<< Research Monitoring - Throughout the year, EcoCloud will enable Affiliates to remain engaged by means of newsletters, seminars, talks and virtual meetings. When feasible, these events will be broadcast live for our IAP member companies, so participants can join in remotely to hear from different thought leaders at EcoCloud and keep informed about the latest research. Affiliates also have access to the comprehensive information about research outcomes, EcoCloud events, video and publication archives, and other research outputs.

<< Graduate Student Recruiting - EcoCloud will organize events (including the Annual Event), during which Affiliates have access to soon-to-be graduating students to facilitate recruiting. We work with our Affiliates to facilitate recruiting activities throughout the year, including advertising job and internship announcements, hosting talks and seminars, and other student-targeted networking events.

<< Occasional Visits - Affiliates may arrange visits to EcoCloud's affiliated laboratories and the experimental facility created in the new data center of EPFL. Visits enable previews of EcoCloud's research programs and results and demonstrations of emerging technologies. We work with our Affiliates to identify appropriate EcoCloud researchers, ongoing projects and potential opportunities for collaboration.

INDUSTRY AFFILIATES
MEMBER BENEFITS

<< Joint Research Projects - Member companies have opportunities to engage with EcoCloud in research projects and collaborations into deployable technology. These include, but are not limited to: the opportunity to contribute and formally participate in EcoCloud research projects, customization of educational programs and the opportunity to develop and sponsor structured research programs.

<< Advertising - Our affiliates have the opportunity to promote their company's brand on EcoCloud's website and reports.

<< Outreach and Executive/Continuing Education - EcoCloud develops and hosts at least two outreach programs per year. Past events included a summer workshop on cooling technologies, a winter school on data-centric systems, and co-hosting the 3D silicon integration conference. Moreover, EcoCloud is eager to develop special executive courses, as well as continuing education courses, to address the specific needs of our affiliates.

<< Technical Advisory Board - EcoCloud Affiliates designate a technical staff to the EcoCloud Technical Advisory Board which meets once a year to discuss grand challenges, research and industrial trends, and EcoCloud research direction. This annual meeting can vary from a one-hour meeting to a full-blown two-day retreat to present research and solicit feedback.

<< Visiting Scholars and Fellows Program - The EcoCloud Visiting Scholar and Fellows Program stimulates and supports our research by engaging promising scholars and practitioners in order to foster exchange. Each year, a number of distinguished academics (Visiting Scholars) and junior faculty and students (Fellows) will be selected on the basis of their qualifications, the quality of their research plans, and the relevance to both EcoCloud's mission and targeted research objectives. EcoCloud's Visiting Scholars and Fellows will work on projects that offer joint collaborative opportunities.

CURRENT ECOCLOUD AFFILIATES
IN ALPHABETICAL ORDER

SWISSCHIPS:
COMING TO THE DEFENSE OF SWISS CHIP DESIGN

The State Secretariat for Education, Research and Innovation (SERI) is to invest CHF 26 million in the development of chip design, with partners ETHZ, EPFL and CSEM contributing a further CHF 7.8 million. The SwissChips initiative is setting out to defend Switzerland's position as a world leader in this vital technology.

Of the EPFL professors involved (Stephanie Lacour, Adrian Ionescu, Andreas Burg, David Atienza) all were Principle Investigators at Nano-Tera, and half are currently members of EcoCloud. These are exactly the kinds of synergy, built on academic excellence, that SwissChips is designed to foster.

Prof. Luca Benini, Chair of Digital Circuits and Systems at ETH Zurich

Two of the leading players in Swiss integrated circuit design are Prof. Luca Benini of ETHZ and Prof. David Atienza of EPFL. Their collaboration goes back a long way, including Nano-Tera project YINS.

As keynote speaker at the EPFL EcoCloud Annual Event last year, Benini made the point that RISC-V technology, which is open source, scalable and extendable, is the way forward for chip design.

"We are seeing a move towards Embodied AI technology," explains Benini, "that can produce results in a physical context, such as robots or satellites. In the face of such challenges it is such an advantage to be able to optimise an architecture from the instructions to the system, and RISC-V makes this possible."

A good example of a Swiss chip design based on RISC-V technology is X-HEEP, a low-power wearable chipset architecture that can be used for a huge range of biomedical sensing applications. A product of Atienza's Embedded Systems Lab at EPFL, X-HEEP was recently featured in the EUROPRACTICE annual report.

Another is PULP, which was developed by Benini's Integrated Systems Laboratory at ETHZ. Its stated aim is to break the energy efficiency barrier within a power envelope of a few milliwatts, while receiving the data streams generated by multiple sensors, such as accelerometers, low-resolution cameras, microphone arrays and vital signs monitors.

SWISSCHIPS:
COMING TO THE DEFENSE OF SWISS CHIP DESIGN

It is clear that EPFL collaborators have been using and contributing to ETHZ's PULP technology, and that in return ETHZ have also been developing work on EPFL's X-HEEP architecture.

Once you add CSEM, with their vast expertise, hardware resources and industrial network, you get exactly the kind of holistic design culture that SERI is hoping to encourage, especially given that Switzerland has left the Horizon program of European funding, and other EU funding programs.

If we are not designing chips, we are out of the game

We spoke to two co-leads of SwissChips, Dr. Alexandre Levisse and Dr. Miguel Peón of EPFL.

"When monitoring illnesses such as cardiac and epileptic conditions, off-the-shelf integrated circuits for detecting seizures can work," explains Alexandre Levisse. "However, current microcontroller architectures lack energy efficiency, versatility and scalability, particularly in the context of applications leveraging artificial intelligence, making them extremely inefficient. One of our goals is to explore and design circuit architectures which can meet these needs.

"Being part of programs like SwissChips enables us to teach young engineers and researchers how to design chips and develop open-source hardware platforms such as X-HEEP and PULP. With SwissChips, we intend to foster scientific collaboration between Swiss universities in the field of integrated circuit design through the development of common design platforms and chips designed together."

The current reputation of Swiss chip designers is remarkably high, as Miguel Peón explains: "Until now, Switzerland has produced a surprisingly high amount of chip designs for the size of the country. EUROPRACTICE has just published a graph of the number of chip designs that they received from each country in Europe in 2023. Switzerland is third, behind only France and Germany. That is amazing!

"But these designs were mostly developed while Swiss universities were still participating in European-funded research programs. Switzerland is no longer a member of Horizon Europe and other programs, so the future of Swiss chip design depends on initiatives like SwissChips."

"Although Switzerland does have some foundries," states Levisse, "manufacturing chips for watchmaking, automative and other industries, it is not a country that mass-produces chips like Intel (USA) or TSMC (Taiwan).

"If we can't manufacture chips, and we are not designing them either" explains Peón, "we are out of the game."

According to Prof. David Atienza, the game is getting harder: "In the current geopolitical context the USA, China, India and the EU are giving clear indications of technological decoupling, and the development of their own digital ecosystems.

"The SwissChips initiative is essential to ensure that there is a strong Swiss network sharing infrastructure, methodologies and technologies, in order to stay at the forefront of integrated circuits and microelectronics design in the years to come."

Above: Prof. David Atienza of ESL
Title picture: Miguel Peón-Quirós and Alex Levisse

OUR NEW EXPERIMENTAL FACILITY IS UP AND RUNNING

As promised in previous announcements, the new EcoCloud Experimental Space is running, and experiments are underway.

The facility is located in the CCT Building, alongside the EPFL Data Center and above the campus central heating plant.

There are currently eight racks with passive rear door liquid/air exchangers. A large experimental area is dedicated to projects that target energy monitoring and different approaches to liquid cooling, with the possibility of two experimental liquid loops.

Each rack is equipped with a per-plug power monitoring system, allowing full bench marking and computing optimization.

The experimental space has an allocation 150 kW of cooling for the racks and 2 * 50 kW for the experimental space.

One of the main projects that is going to be hosted in the Experimental Space is Heating Bits, financed by EPFL S4S. This project includes heat recovery from the servers at a temperature that enhances the co-generation of electricity and/or redistribution to the central heating system. In addition, its battery system is carefully monitored so that the quantity of renewable energy is optimized, and the workload suited to the amount available.

CORINTIS KEEPS PROVING
IT IS THE COOLEST THING AROUND

Corintis SA has finished 2nd out of 100 entries in the Top 100 Swiss Startup Award.

This amazing achievement meant that Corintis were the only entry in the top 20 from the category Engineering.

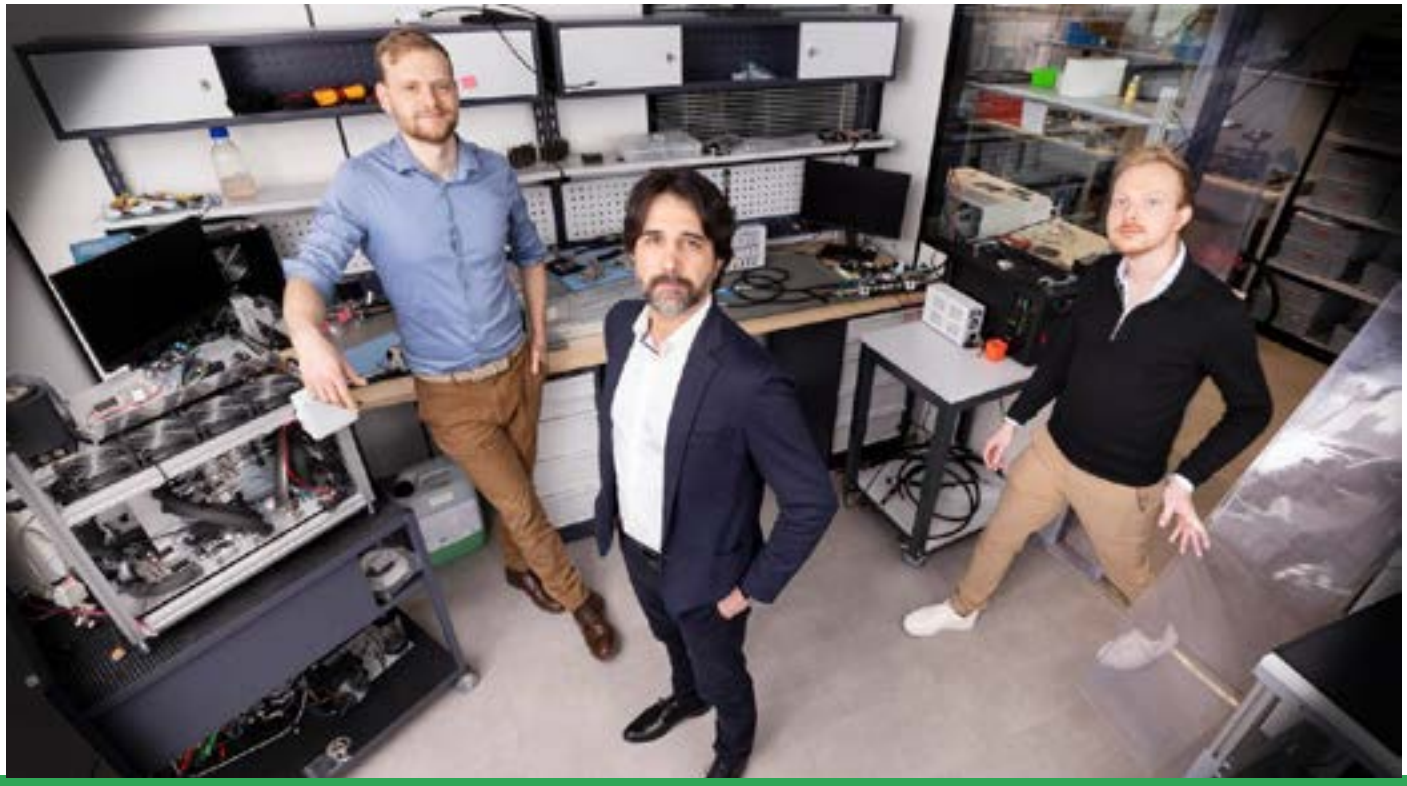
Corintis is a spin-off from the POWERlab of Prof. Elison Matioli, who has been a member of EcoCloud for a number of years.

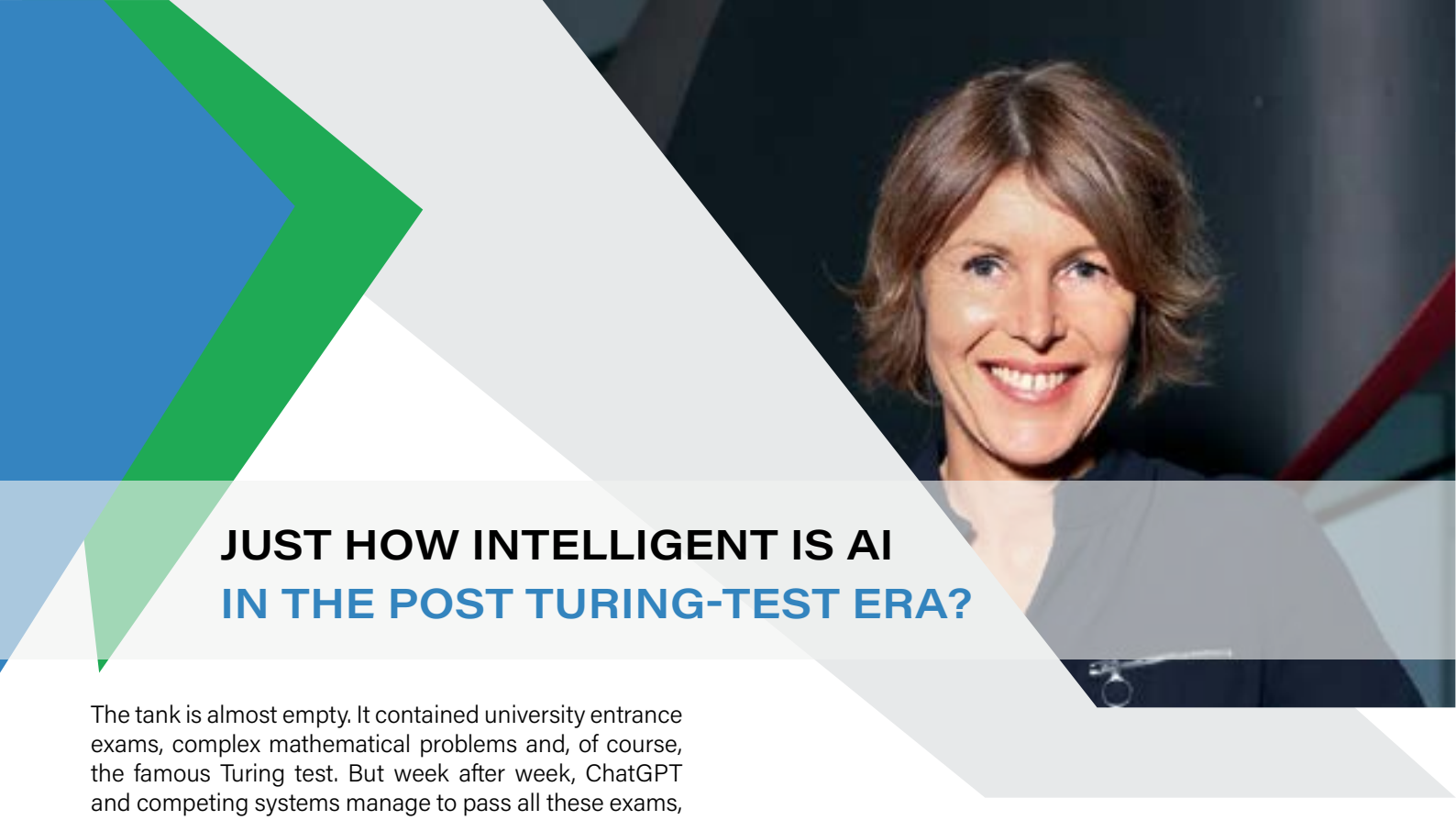
This company offers chip manufacturers a unique service. Microchannels of varying diameter provide a cooling system that is tailored to the needs of each chip, as part of a cooling network designed for the entire machine – the hot spots having been identified in advance. Crucially, it is only the hot spots themselves that are targeted – an ultra-efficient strategy.

Corintis are in full expansion mode, and are currently recruiting.

corintis

Above: Sam Harrison and Remco van Erp of Corintis
Below: Sam Harrison, Prof. Elison Matioli, Remco van Erp





JUST HOW INTELLIGENT IS AI IN THE POST TURING-TEST ERA?

The tank is almost empty. It contained university entrance exams, complex mathematical problems and, of course, the famous Turing test. But week after week, ChatGPT and competing systems manage to pass all these exams, with increasingly high scores. Hence the idea, launched this week, to find other ways of judging the progress of ultra-high-performance artificial intelligence (AI) services. This race is gathering pace, as calls to regulate this technology have multiplied in recent days.

Earlier this week, the Center for AI Safety (CAIS), whose mission is to minimize the risks caused by AI, in association with start-up Scale AI, launched an appeal. "Humanity needs to maintain a good understanding of the capabilities of AI systems. Existing tests have become too easy, and we can no longer properly track the evolution of AI, nor know what it lacks to reach expert level", according to CAIS, which has thus proposed a competition, called 'Humanity's Last Test.' Its aim: to create "the most difficult AI test in the world."

$5000 for the winners

From now until November 1, anyone can submit a test. The questions must be difficult for non-experts and cannot be solved by a quick online search, says CAIS, which warns, "Do not submit questions relating to chemical, biological, radiological, nuclear weapons, cyberweapons or virology." The authors of the 50 questions deemed most interesting will receive $5,000 each, with the next 500 questions rewarded with $500.

What about this search for new tests to measure AI progress? "Ensuring the robustness of AI models and their correctness is vital for adoption, as we know that today we can't trust them blindly. So, yes, the search for effective tests is highly relevant. That's what Turing was trying to do with his test of the same name," says Anne-Marie Kermarrec, professor of large-scale distributed systems at EPFL.

According to the expert, "AI is progressing at a very high speed to 'imitate' human reasoning by performing increasingly complex tasks. As far as creativity is concerned, which can be defined as producing new objects, for example artistic ones, we can consider that AI is indeed capable of producing new works of art such as poetry, songs, music or paintings. Human creativity, on the other hand, cannot be judged by the same criteria."

As proof of this progress, a week ago OpenAI launched the o1 version of ChatGPT, capable, according to the American company, of "reasoning". "In a qualifying exam for the International Mathematical Olympiad, GPT-4o solved only 13% of the problems correctly, while the reasoning model scored 83%," boasted OpenAI. Success stories of this kind have been multiplying in recent months. In January 2023, an earlier version of ChatGPT passed exams at a US law school after writing essays on topics ranging from constitutional law to taxation to torts.

Turing Test Achieved

And in June of this year, researchers at the University of San Diego claimed to have put ChatGPT through the Turing test mentioned above by Anne-Marie Kermarrec for the first time. In a nutshell, this test, proposed by British mathematician Alan Turing in 1950, consists in determining whether a machine can imitate human intelligence to the point where a person would not be able to distinguish the machine from another human being during a conversation. In the case of the San Diego test, more than half of the 500 participants mistakenly thought they were conversing with a human.

JUST HOW INTELLIGENT IS AI
IN THE POST TURING-TEST ERA?

Are we moving towards AIs capable of "reasoning", as OpenAI claims for the o1 version of ChatGPT? "This version is based on a more complex model, which takes more time to respond - which, incidentally, is not proof of more thinking, but of more calculations," asserts Anne-Marie Kermarrec. The professor continues: "I wouldn't go so far as to say that these models reason. They exploit data even more, and in different ways. Moreover, this increased complexity risks complicating explicability and transparency. For the time being, the notion of reasoning seems to me to be a marketing issue, even if I have no doubt that these models can handle more complex tasks than their predecessors. It's more a question of the ability to mimic reasoning well."

The above article originally appeared in Le Temps, and was written by Anouch Seydtaghia

Appointment to the inaugural Presidential Science Council of France for Prof. Anne-Marie Kermarrec

EPFL Professor Anne-Marie Kermarrec has been appointed by French President Emmanuel Macron to the newly established Presidential Science Council.

In December 2023 Emmanuel Macron announced the creation of a 'Presidential Science Council' to be made up of 14 high-level scientists representing all disciplines. The Elysée Palace announced that the new body illustrated Macron's wish to place science at the heart of public decision making.

Anne-Marie Kermarrec, a professor at EPFL since 2020, who heads the Scalable Computing Systems Laboratory in the School of Computer and Communication Sciences recently joined 12 inaugural appointees to the Council.

"It's a real honor to be part of the French Presidential Science Council and, needless to say, I am in excellent company. Science holds considerable importance in our society, and its impact continues to grow with areas like artificial intelligence, cybersecurity, and digital sovereignty, which particularly concern me as a representative of computer science in this body," said Kermarrec.

Before joining EPFL the professor was CEO of the start-up Mediego, founded in 2015, providing content personalization services for online publishers. Previously, she was a Research Director at Inria, the French National Institute for Research in Digital Science and Technology.

With research interests focused on large-scale distributed systems, epidemic algorithms, peer to peer networks and system support for machine learning, Kermarrec was elected to the European Academy in 2013 and named ACM Fellow in 2016 and she is looking forward to contributing to science dialogue at the highest level in France and highlighting major and emerging issues in terms of research.

"Emmanuel Macron's determination to place science at the heart of political strategy and reflections on the future of the country is excellent news. In addition to raising the President's awareness of pressing scientific issues, this committee also represents a unique opportunity to discuss the future of the scientific research in France," Kermarrec concluded.

Anne-Marie receives the title Chevalier de la Légion d'Honneur in 2019

PREDICTING PATTERNS
OF THE FUTURE

According to Prof. Martin Kemp, in a talk he gave at EPFL in 2011, if Leonardo da Vinci looked at ripples of water, long wavy hair or wispy clouds, he always saw the same thing - patterns. To a Renaissance man these patterns were simply different manifestations of similar phenomena. According to one author, Leonardo even used such patterns to predict the weather.

In many fields of modern science, professors have returned to this mode of thinking. For example, when Prof. Olga Fink looks at railway networks, power supply systems, and even the human brain, what fascinates her most is what they have in common: they are interdependent nodes, arranged in vast networks, that interact with each other. These interdependencies: how they interact, how one can model their dynamic behaviour, are at the beating heart of the Laboratory of Intelligent Maintenance and Operations Systems (IMOS) - and they too allow for predictions of the future.

Prof. Fink's research addresses a broad spectrum of applications, from hydropower plants and the rolling bearings of large-scale wind turbines, to ensuring the reliability of aircraft engines. Her work combines engineering and computing technologies that can predict a system's changing condition over time, and to anticipate potential future maintenance issues.

"Machine learning is undeniably powerful at processing data," explains Prof. Fink, "but it struggles with applying this data to previously unseen operational regimes, or to different environmental conditions. We develop algorithms with two key capabilities: first, we incorporate the laws of physics, enabling them to generalize better, and become more interpretable - both crucial, for real world scenarios. Secondly, we make sure they are robust in the face of changing operating and environmental conditions, such as fluctuations in temperature and load, by integrating the operating condition context into the process of extracting node dynamics.

PREDICTING PATTERNS
OF THE FUTURE

There are many parallels between our work and neuroscience.

For us, networks of sensors have a lot of similarities to nodes and synapses

Drawing of cloud formations by Leonardo da Vinci
Left top: Prof. Olga Fink and, below left, her Lab team

"And sensor networks can be extremely complex. They are often characterized by high dimensionality, dynamic topologies, and sensor heterogeneity (e.g. with very different time resolution), all of which are further influenced by varying environmental and operating conditions."

This kind of research is inherently multidisciplinary. "We have researchers with many different skill sets. Although most have an engineering background, with an understanding of computing, some are the opposite. It is sometimes difficult to convince computing experts to dive into the world of physics, but that is our mission.

"We also have a neuroscientist in our team. There are many parallels between our work and neuroscience. For us, networks of sensors have a lot of similarities to nodes and synapses."

The research of IMOS benefits from collaborations with industry, which ensure that their research addresses real-world problems, and that their developed approaches are tested on real data. For research into renewable energy hardware, such as hydropower plants, they collaborate with SBB Energy. There have also been collaborations with NASA, on remaining useful lifetime prediction.

The recent Intelligent Maintenance Conference featured talks from representatives of CFF, Airbus, SNCF and Alstom.

Such is the multifaceted research of the Laboratory of Intelligent Maintenance and Operations Systems. Prof. Fink recalls an industrial partner once making the point that the problems her algorithms were predicting were issues that would only become relevant for the industry more than ten years into the future:

"I took it as a compliment. That is exactly what we are aiming for - preparing, getting ready for the future."

ADAPTABLE MICROCHIPS FOR DATA CENTERS:
HUGE GAINS, NEW DANGERS

Demands on cloud services continue to increase but the end of Moore's law means that transistors are no longer getting significantly smaller every year. Heterogeneity is the answer: servers need flexible platforms.

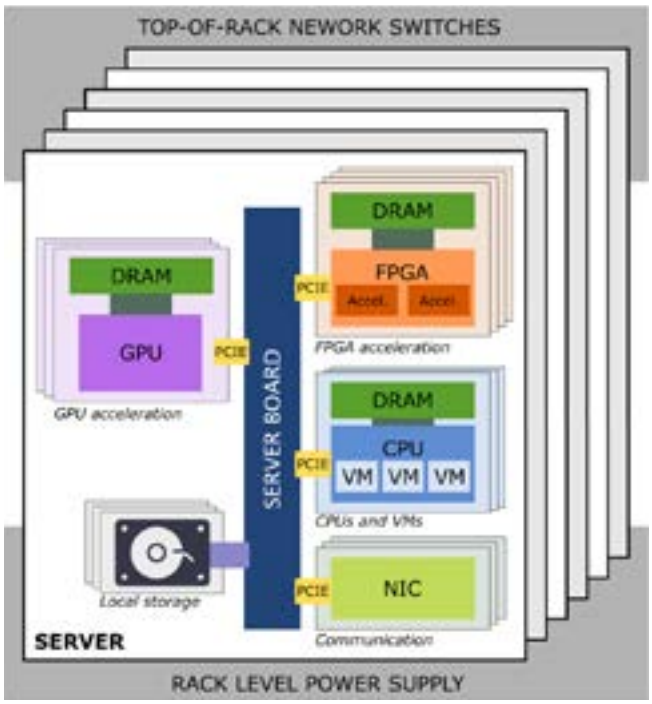
Field-programmable gate arrays, or FPGAs, are semiconductor devices so adaptable that they can be reconfigured at runtime. Most integrated circuits are built with at least some set of specific tasks in mind, but FPGAs are built to behave like almost any digital circuit by simply reconfiguring their hardware.

Mirjana Stojilovic, a scientist in IC's Parallel Systems Architecture Laboratory (PARSA), is the lead author of the recent cover article in the latest edition of the prestigious IEEE Proceedings. The article is entitled: A Visionary Look at the Security of Reconfigurable Cloud Computing | IEEE Journals & Magazine | IEEE Xplore.

The article is both a survey of the current state-of-the-art use of FPGAs in cloud computing and a prediction of how this technology will evolve in the face of multiple security risks. It outlines that Microsoft led the way in embracing the potential of FPGA technology for data center applications: its Catapult servers relied on FPGAs to accelerate the Bing search engine. Since then, Amazon AWS, Alibaba, Baidu, Microsoft Azure, and others have followed suit.

However, FPGAs in data centers bring security risks. They can empower a malicious user to execute a variety of remotely-controlled electrical-level attacks: denial-of-service, fault injection, power side-channel, and crosstalk side-channel attacks. "The problem is that the FPGAs themselves – their architecture, their implementation – allow the users to deploy circuits of almost arbitrary complexity, which is great for many applications but can also be misused," explains Stojilovic.

Malicious users can build circuits to sense signals from



A heterogeneous cloud server architecture: data center chipsets have never been so flexible!

ADAPTABLE MICROCHIPS FOR DATA CENTERS:
HUGE GAINS, NEW DANGERS

another FPGA that is not allocated to them. They can create fluctuations in the power supply that might reset the entire device or cause errors in someone else's application simultaneously running on the same FPGA.

"There are barriers to malicious attacks, but we have observed that it is possible for sophisticated attackers to pass right through them. We make it clear in our article that data center managers have to apply a holistic approach: safety measures must be deployed across all levels!" she continued.

"We were able to set up a demonstration to show engineers from Amazon that they were open to certain types of attack," explains Stojilovic. They reacted by deploying defences against these threats, and also by slowing down the roll-out of simultaneous FPGA sharing. Ideally, from a data center perspective, an FPGA should be open to several users at the same time, but the security risks are too great for that – and Amazon recognized it."

In From the Earth to the Moon, Jules Verne pitted the cannon foundries against armour plating manufacturers, in constant rivalry, each attempting to outdo the other in ingenuity. FPGA pits the hypervisor against the hacker,

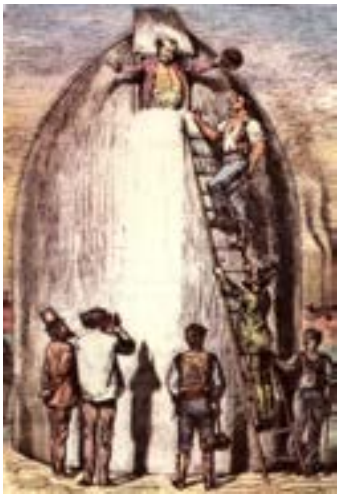


Illustration from De la Terre à la Lune by Henri de Montaut

and for data center operators this means they will have to be ever vigilant, as Stojilovic states in her conclusion:

"Such awareness should be the guiding assumption when designing mitigation mechanisms that should necessarily be tackled in a holistic manner, to allow for continuous updates to address the evolving attack surface."

Top left: Dr. Mirjana Stojilovic
Below: Dr. Stojilovic received a television crew from Serbia to discuss data center security

CLEARSPACE WILL USE MINORITY REPORT TECHNOLOGY FROM EPFL

Satellites are open to attack. All communications systems are vulnerable to hackers by definition, and are protected accordingly, with hardware and software. However, because they reside outside the protection of the Earth's atmosphere, satellites are perhaps exposed to the mightiest and most unpredictable hacker of all: the Sun.

"The Sun's radiation can affect the data being processed in any system in space," explains Rubén Rodriguez Álvarez, a doctoral assistant at ESL, the Embedded Systems Lab. "The radiation causes bits to flip, so your data is polluted with interference, and you might not even know that this is happening."

All traditional computing systems use binary logic: bits of binary values of 1 or 0, stored as electrical charges. If any process randomly changes the value of your bits, your data is corrupt.

The knee-jerk reaction to protect a system from radiation would be to install reflective shields, but this is exactly the kind of heavy duty solution that satellite engineers are keen to avoid.

"An idea from my colleague, Dr. Miguel Peón-Quirós, seemed to provide a better way: using a software solution that had been pioneered by another researcher in our lab," explained Rodríguez. "Miguel suggested using Flavio's technology to provide a solution to the problem of radiation interference without an increase in overhead, either of hardware or software."

The Flavio mentioned above is Dr. Flavio Ponzina, recently graduated from ESL, and now a Postdoctoral researcher at the University of California, San Diego. "E2CNN is a technique where we take a neural network, prune it carefully, and then send multiple copies of it down separate channels," explains Ponzina. "We send the same neural network of data through multiple channels, for the sake of redundancy. If radiation, or any other kind of interference, affects the information in one of these instances, the other ones will be given credibility over the one with the corrupt data."

6DoF or six degrees of freedom: translations (sliding movements) around the three geometric axes: x, y and z; plus rotations around the same three axes

A satellite's positional data is usually processed as 6DoF. This complex data is compiled from sensor data and stored in a dynamic model: a convolutional neural network, or CNN. Video data from the satellite's optical sensors is also stored in CNNs.

Sending these neural networks of data down multiple separate processor channels means that even if one of these models is hit by a burst of radiation, the version reported over the other channels will outvote the minority version. Those familiar with Philip K. Dick's Minority Report, or the movie based on it, might recognize the concept.

"We use an intelligent method to prune the neural network before we send it down separate channels, to reduce the size of the model," explains Ponzina. "This means that, even though we send it down multiple channels, there is no decrease in processing speed. But there is actually an increase in accuracy of 5%, even without radiation interference! If we simulate radiation interference, accuracy goes up by 9%."

For some time this technology has been known to ClearSpace SA, the EPFL spin-off that intends to launch satellites to remove space débris from Earth's orbit. ClearSpace-1 will take off some time in the next few years, using the protective system described above.

Now that Ponzina has left EPFL, it is Rodríguez who is continuing the project, implementing the software on

CLEARSPACE WILL USE
MINORITY REPORT TECHNOLOGY FROM EPFL

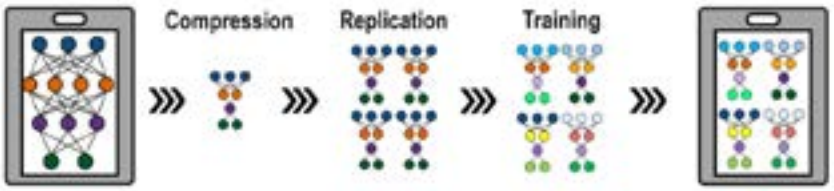


Figure 1: E^{2}CNNs methodology. The baseline CNN model is first compressed. Then, the obtained structure is replicated multiple times to build an ensemble. The individual training procedures result in different weights distributions among the replicated instances, ultimately improving accuracy and robustness.

FPGAs - Field Programmable Gate Arrays, a technology uniquely suited to this kind of application. FPGAs are modular chips: processors that can change shape according to the requirements of the application. In this case, they adapt wonderfully well to the sending of neural networks down multiple parallel channels.

Jacques Viertl of ClearSpace, formerly a member of the EPFL eSpace Center, is clear on the benefits of this system: "We asked for an implementation on FPGAs because of the redundancy they offer. Whenever you deal with images there is a trade-off between quality and overhead, but in the case of the visual recognition of targets by ClearSpace-1, the processing of the information will be protected by the multiple channels being used, at no extra cost in processing power.

"The connection between ClearSpace and EPFL is really strong," explains Viertl. "To us, student projects mean a supply of youthful energy, fresh ideas, and technology transfer.

"It is more often we who are asking for student collaboration, than the other way around. The fact is, it is extremely difficult to find engineers in the domain of FPGAs. We spoke to one student, recently, who told us that we were one of seven companies offering them a placement!"

This synergy between the Embedded Systems Lab and ClearSpace exemplifies the collaborative energy of the the EPFL EcoCloud Center. "It is very important for us that the research we do in edge AI and smart embedded systems can be applied to the context of space technology," says Prof. David Atienza, Head of ESL. "ClearSpace had a great understanding of the constraints of the final system, and it helped us to tune accordingly all the AI/ML algorithms and performance of the system to meet such constraints.

"It is very helpful for EPFL researchers to see that the research they do can be applied to the real world, but this can only happen if we work with companies that deploy the final systems."

These are exciting times: science fiction is quickly being outpaced by reality, established technology companies are looking to the youngest engineers for skill and inspiration, and our labs keep finding ways to solve the toughest problems - like how to stop the Sun from flipping our bits.

The above illustration is from a paper by Flavio Ponzina presented at SPAICE Conference 2024, and published in NASA's proceedings.

clearspace today

THE 2024 SDEA LABEL IS PUBLISHED:
SETTING THE STANDARDS FOR DATA CENTERS

Every time we book a hotel online, stream a movie or make a video call, data centres worldwide consume a lot of energy and water. A label launched in Switzerland wants to reduce the environmental and climate impact of our digital habits, and position the Alpine confederation as a location for greener data centres.

In January 2017, Puerto Rican singer Luis Fonsi released a single that would go down in history. In the first six months, the Despacito video clip was viewed 4.6 billion times on YouTube. Today it's been seen more than eight billion times, but there's an even more astonishing figure. According to estimates, the streaming of Despacito consumed more electricity than the power used by 10,000 households in Switzerland in one year.

Data centres consumed the most of this power. They are the buildings containing the servers and physical infrastructure to manage email traffic, store our photos in the cloud – or in this case, run platforms such as YouTube.

"Data centres have become the pillars of the digital economy. However, we don't know how sustainable their energy consumption is," says Babak Falsafi, professor of computer science at the Swiss Federal Institute of Technology EPFL in Lausanne and president of the Swiss Datacenter Efficiency Association (SDEA), a consortium of companies and academic institutions.

According to the International Energy Agency, thousands of data centres and transmission networks worldwide use about two per cent of global electricity. Data centres also need a lot of water link to cool the servers.

With the rapid growth of artificial intelligence, Falsafi explains, we are seeing an increase not only in the number and size of data centres, but also in their energy consumption and carbon footprint. But he argues that higher energy efficiency standards could reduce the impact of data centres on the environment and climate.

The SDEA presented a new efficiency label in 2020. However, the certification has "really picked up speed" since this year and has gotten "international visibility," with interest coming from Switzerland as well as other European countries, according to Falsafi. Starting July 16th, all companies operating data centres or renting a space for their servers can register and use the SDEA's energy efficiency calculator link with the option to eventually apply for certification.

The traditional indicator of energy efficiency is the Power Usage Effectiveness. The PUE measures the electricity consumed by IT infrastructure (compared to the total energy used by the data centre) but gives no indication of how efficiently IT equipment uses that electricity.

On the other hand, the SDEA label, which is supported by the Swiss Federal Office of Energy (SFOE), considers the entire energy balance of a data centre. For example: the CO^2 emissions generated by the electricity source and the energy efficiency of servers, storage systems and network devices.

The label places special emphasis on the reuse of heat generated by servers. In 2019, only one in three data centres in Switzerland made use of waste heat, according to a study. The heat could heat nearby buildings and power industrial processes, helping to reduce the consumption of fossil fuels.

A data centre operator can decide whether to have an independent auditor assess only the building infrastructure, the IT system infrastructure or both. Based on the evaluation report and the established criteria, the SDEA awards a bronze, silver or gold label. The certification is valid for three years. A new assessment after this period encourages participating companies to invest in energy saving measures.

So far, the SDEA has awarded the label to three data

THE 2024 SDEA LABEL IS PUBLISHED:
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centres belonging to Hewlett Packard Enterprise (the technology company that initiated the consortium), the financial group SIX and the telecommunications company Swisscom.

SIX, which was certified for the whole infrastructure, did not want to disclose the measures taken to improve energy efficiency and the savings achieved. SDEA claims, based on the results of the pilot phase of the project, that implementing the requirements for obtaining the label would save up to 70 % of previous energy consumed by a data centre.

Another eight data centres are in the process of certification, says Falsafi, without naming the companies involved. Discussions are also currently underway with data centre operators in Austria, Germany and Scandinavia, he says.

The SDEA label is a step in the right direction, according to Marco Bettiol, professor at the University of Padua in Italy and author of a study on the environmental sustainability of data centres. It would allow data centres to precisely measure their impact, including CO^2 emissions.

But this approach has limitations because it only considers direct emissions. "We cannot underestimate the indirect emissions related to the manufacture of chips and all digital devices used in data centres," Bettiol points out.

A data centre has a lifespan of 15-20 years. But for security reasons, digital equipment is usually replaced every five years on average, he says.

Making Switzerland a top location for greener data centres

With the label, the SDEA also wants to position Switzerland as a reference country for climate-friendly data centres.

Switzerland, with its service-oriented economy, political stability and competitive energy costs, is among the countries with the highest number of data centres per capita in the world, according to datacentermap.com.

The Zurich region is among the most attractive emerging markets for cloud service providers, along with the Lake Geneva region. Switzerland is also among the 20 industrialised countries with the greatest growth potential in the field of generative artificial intelligence, according to a recent report by PricewaterhouseCoopers.

Switzerland is particularly well suited to operating data centres in the most environmentally friendly way possible, says Adrian Altenburger, professor of building technology and energy at Lucerne University of Applied Sciences and Arts and co-author of a study on data centres in Switzerland. He points to the already high share of renewables – around 60 % of the electricity generated in Switzerland comes from hydroelectric power plants, and there is potential for expansion.

However, this development is not without repercussions. Data centres in Switzerland use almost four per cent of the country's total electricity, and in the coming years their electricity consumption will "increase massively," predicts Altenburger. It cannot be ruled out that the country will have to adopt restrictions on the construction of new data centres to avoid overloading the electricity grid, he warns.

In Ireland, where data centres use almost 18 % of the country's electricity, the national electricity company has introduced a moratorium until 2028 for new facilities in the Dublin area. In the past, Germany, Singapore and China have also imposed restrictions on the development of new data centres.

SDEA's label could help avoid such a scenario and "significantly" improve the efficiency of data centres in Switzerland, says Altenburger. The potential for electricity savings is high: according to a 2021 study commissioned by the SFOE, data centres in Switzerland could reduce their consumption by 46 %.

However, Altenburger emphasizes that a voluntary label is not enough to make data centres greener. Regulations or laws that define requirements for energy efficiency are also needed. In the canton of Zurich, the Energy Act of 2023 obliges data centre operators to reuse waste heat.

Of course, we can all contribute to reducing the energy consumption of data centres by changing our digital habits. For instance, by regularly emptying our e-mail inbox, downloading digital content to our device instead of playing it online or reducing the quality of streaming.

And having viewed the Despacito video clip 8 billion times, just listening to the music might be enough.

This article was orginally published at Swissinfo.ch, and was written by Luigi Jorio.
Top left: Prof. Babak Falsafi, at the EPFL CCT building.

ADVANCED THERMAL MANAGEMENT
WITH GEMATEG

People are making increasingly large demands of "The Cloud", from ever larger data backups to multiplying numbers of virtual machines. In turn, this means that data centers need to use more energy to power their infrastructure, and even more energy to keep their machines cool. In order to lower their carbon footprint, and to maximize performance, they need advanced thermal management.

"At EPFL, we continue to identify innovative solutions that optimize workloads of next-generation chips for cloud and AI servers," says Babak Falsafi, Professor of Computer and Communication Sciences at EPFL, and founder of the EPFL EcoCloud center. In order to ground this research, it is vital to work with industry, which explains the strong links between EcoCloud and GemaTEG Switzerland Sàrl.

Maurizio Miozza, co-founder and CCO of GemaTEG, is clear on this point: "We are proud to work together with Babak Falsafi and his team, to help advance and optimize the next generation of sustainable data centers.

"Through our collabration with EPFL, and our participation within EcoCloud, we believe we are developing innovative thermal management solutions that go beyond simple chip cooling, maximizing effectiveness and efficiency at the most fundamental level: chip performance."

According to Youri Markevitch, Director of GemaTEG, their researchers are focussed on fluid dynamics, and the unique properties of silicon. Their two main goals: fulfilling the potential of each chip, and lowering energy consumption.

"The effective deployment of innovative thermal management can enable processing output to achieve the design specifications of each chip," explains Markevitch, "without concern for overheating or damage."

"In addition, deployment of advanced thermal solutions can also decrease resource consumption, leading to efficiency gains of approximately 50%."

Babak Falsafi is clear about the benefits: "Our work with Maurizio Miozza and the GemaTEG engineering team has revealed significant new advancements in thermal management and its impact on processing power, as the world rapidly evolves into data center expansion and the AI paradigm."

In the case of data centers, as in so many domains, A2B collaborations - Academia to Business - are vital, if our care for the environment is going to keep up with our increasing demands on technology.

Pictured are Bruno Lorenzi and Youri Markevitch

GEMATEG

HEEPOCRATES FEATURED IN EUROPRACTICE REPORT

An article on the HEEPocrates chip has been published in the EUROPRACTICE Activity Report 2023.

EUROPRACTICE was launched by the European Commission in 1995 as a successor of EUROCHIP (1989-1995) to enhance European industrial competitiveness in the global market.

A detailed breakdown of the chip and its component processes and features is presented in the 72-page annual report.

The article also describes the collaboration between EUROPRACTICE and the X-HEEP team.

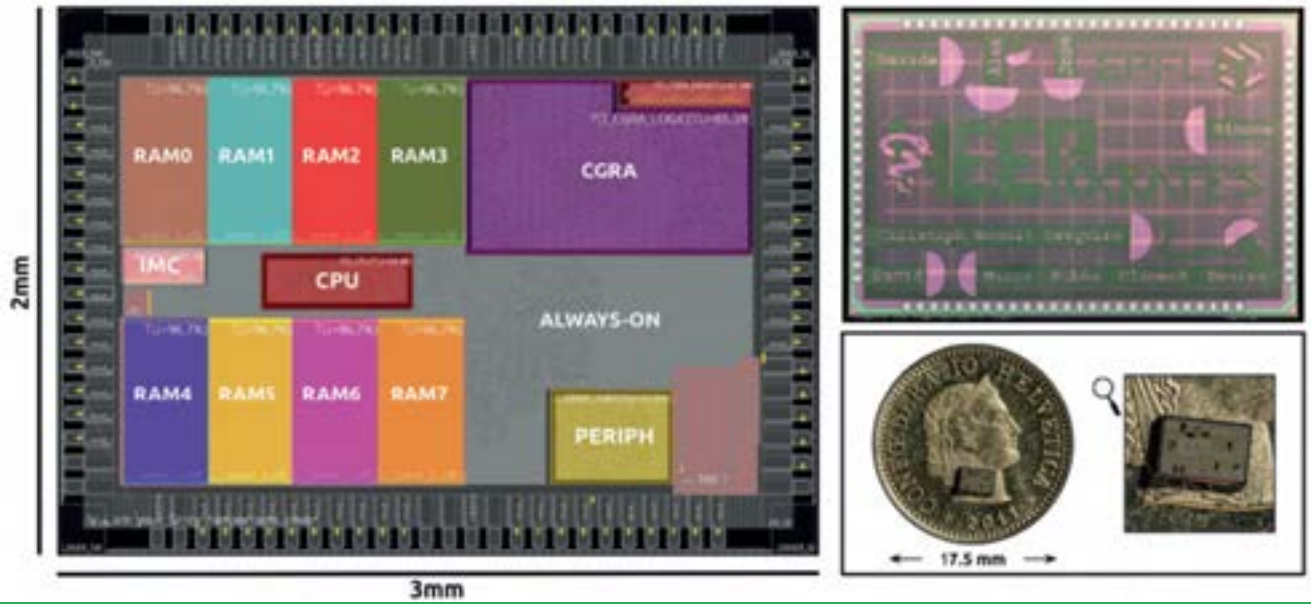
The following is an extract from the report:

"EUROPRACTICE support is a key element in the success of HEEPocrates. Their assistance in acquiring EDA tool licenses, access to technology design kits, participation in their mini@sic MPW program, and the design support from their team, which addresses all sorts of tricky questions, are valuable for universities. Having such a partner is a great asset for EPFL, enabling high-quality research on systems-on-chip."

HEEPocrates is sponsored by the EPFL EcoCloud Center of Sustainable Computing as a key strategic area in cutting edge research.

X-HEEP

Above: the X-HEEP team
Below: the HEEPocrates chip



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Exploring new paradigms in data center hardware technology, pioneering strategies of cloud data management and innovative security techniques, in collaboration with industrial partners

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