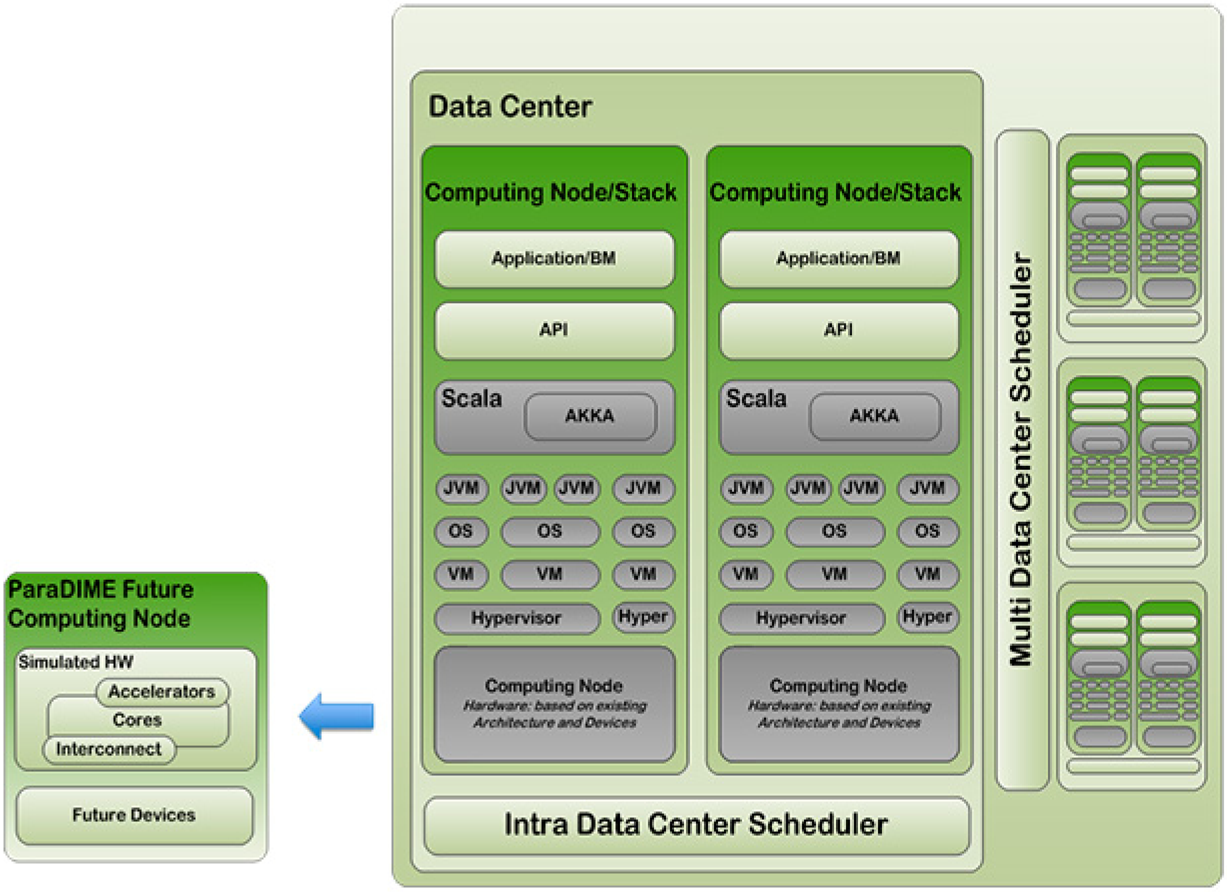
ParaDIME?s innovations offer significant energy savings for data centres



Researchers from the ParaDIME research project, coordinated by Barcelona Supercomputing Center, have successfully developed a number of methodologies which enable savings in data centre energy consumption ranging from 30% to 60%. These methodologies tackle several critical power-related research challenges, from using different current and future devices to inter-datacentre VM (virtual machine) scheduling.

At the **programming model level**, the focus has been on shifting from the shared memory model to an actor-based, message-passing programming model which enables programmers to achieve greater energy efficiency and become more energy aware. There are two illustrative approaches:

- Tailored programming solutions for heterogeneous GPU/CPU architectures. By directly managing the GPU through optimized code, energy consumption can be reduced by roughly 80%. However, this requires in-depth specialist knowledge, which reduces programmability. ParaDIME has developed techniques based on domain-specific languages (DSL) which generate code for both the CPU and GPU, resulting in energy savings of up to 40% while, crucially, empowering a far greater number of programmers to utilize these innovative architectures.

- Tools for power and cost awareness that estimate the power requirements of a single process being run in a virtualized environment. These tools can also be used for user-based pricing models, energy-aware task scheduling and as an indicator for how many heterogeneous resources are consumed by an application.

At the **runtime level**, ParaDIME has developed a large, decentralized infrastructure of small data centres that provide heating and hot water. This is motivated by the efficiency gains demonstrated by the project's industrial partner Cloud&Heat. ParaDIME researchers have developed:

- The multi-datacentre scheduler: this schedules jobs across different data centres, striking a balance between data centre workloads and heating/cooling necessities, resulting in the reduction of CO2 emissions and energy consumption of up to 50%.
- An intra-datacentre scheduler: technologies have been developed to reduce the time needed to reactivate virtual machines and their migration costs. Parts of this work are under review by the QEMU – an open-source machine emulator and virtualizer – community. Institutions using QEMU to virtualize their workload will be able to benefit from ParaDIME-optimized virtual machine migration code. Furthermore, ParaDIME has contributed a feature to track changes to block devices that has already been incorporated into the latest Linux kernel.

At the **hardware level**, ParaDIME researchers have proposed and simulated several methodologies for improving energy-efficiency of the future computing node, including:

- Scheduling of tasks to heterogeneous cores (e.g. big.LITTLE processors, or systems that combine FPGA, GPU and CPU cores). On average, a 40% saving in energy consumption can be achieved by combining FPGA, GPU and CPU cores as opposed to a multicore processor. ParaDIME scheduling also reduces 20% of the power and 35% of the energy on average across different types of heterogeneous platforms. ParaDIME has also researched power estimation tools for a variety of core types.
- Aggressively lowering the supply voltage. Energy is saved by combining this with low-overhead error detection and correction techniques. In addition, ParaDIME researchers have explored this methodology for circuits built with future devices. The ParaDIME methodology saves up to 60% of the energy consumed by the L1 data cache.

About the ParaDIME project

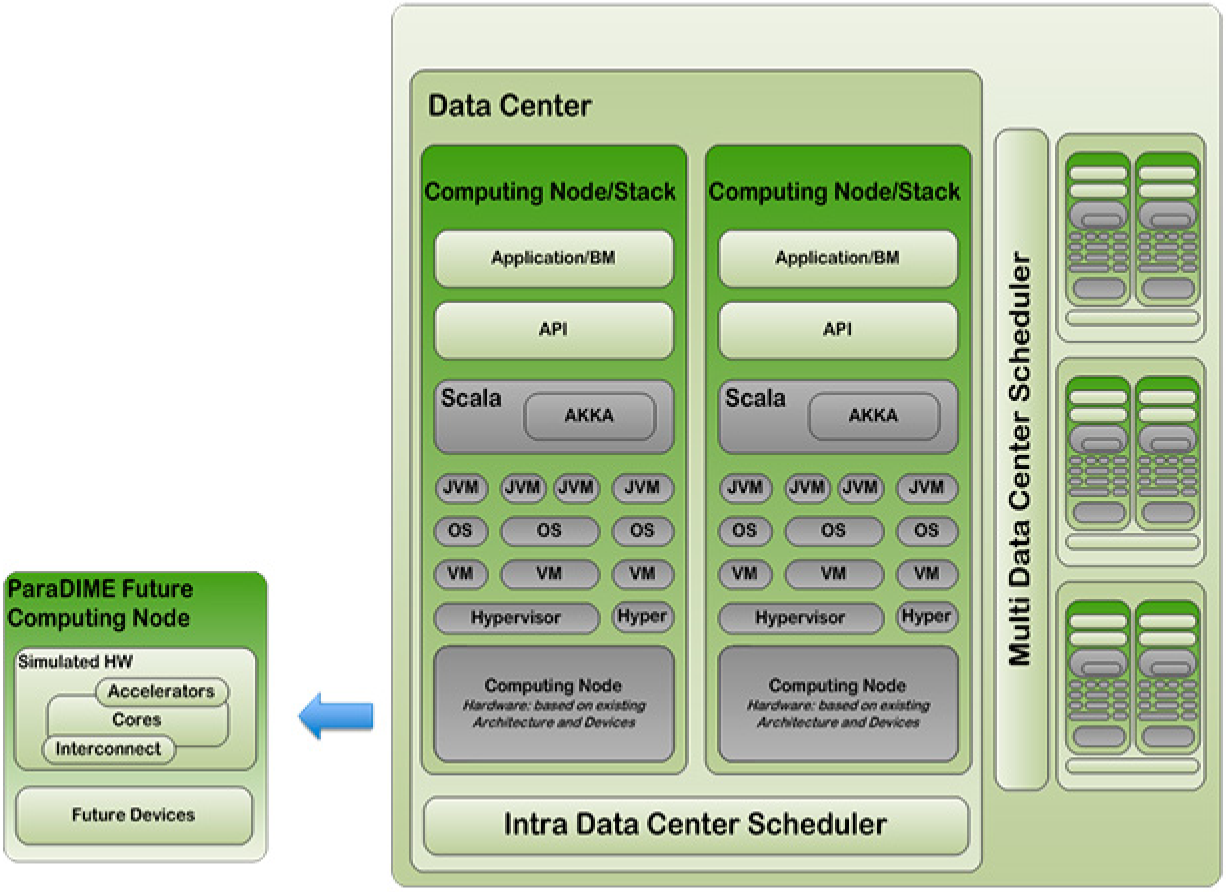
ParaDIME ("Parallel Distributed Infrastructure for Minimization of Energy") was a three-year research project launched in September 2012 with a total budget of €3.2M, including €2.5M funding from the European Commission's Seventh Framework Programme. The project was coordinated by Barcelona Supercomputing Center (BSC) and partners were IMEC (Belgium), Technische Universität Dresden (Germany), Université de Neuchâtel (Switzerland) and Cloud&Heat (Germany).

The objective of this European project was to attack the power-wall problem by radical software-hardware techniques that are driven by future circuit and device characteristics on the hardware side, and by a programming model based on message-passing, and in a smart scheduling of the workload of data centres on the software side.

For further information, visit www.paradime-project.eu

Nota de prensa en español aquí.

Figure 1 ParaDIME infrastructure



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