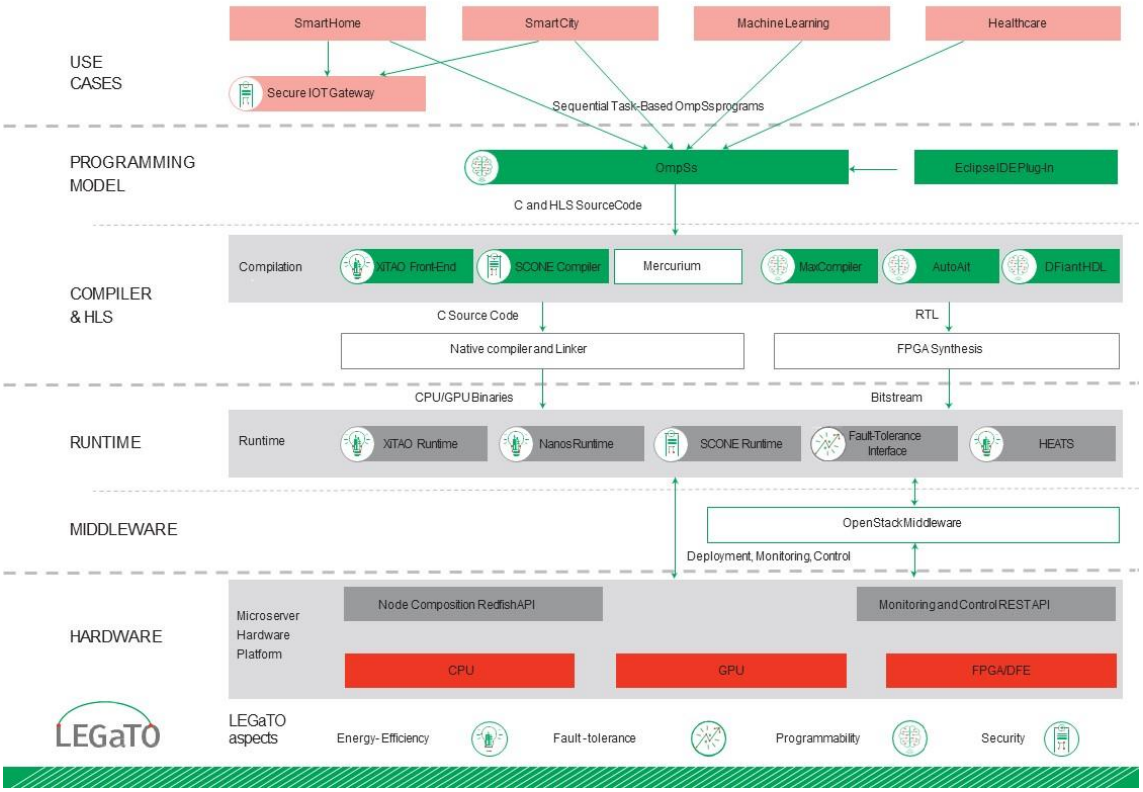
LEGaTO
Low Energy Toolset for Heterogeneous Computing

LEGaTO project concludes with major contributions to energy efficiency in heterogeneous computing

After three years of research, the European-funded project LEGaTO concludes with major contributions to energy efficiency as well as to fault-tolerance, security and programmability. The technologies developed in the project provide up to two orders of magnitude energy savings for five widely applicable use cases. The project results will be used in different levels of European academia, research and industry, and have facilitated the creation of EmbeDL, a spin-off company. In addition, three European-funded projects will build on the outcomes of LEGaTO.

"The work carried out in LEGaTO has already had a significant impact, improving the products and services of our industrial partners and influencing a large number of European research projects, relevant standardization bodies and diverse academic programmes" said Osman Unsal, group manager for the Department of Computer Architecture for Parallel Paradigms at the Barcelona Supercomputing Center (BSC) and coordinator of LEGaTO.

All the components used and developed in the project are arranged in the LEGaTO stack, which gives an overview of the system developed in the project, from use cases to programming model, compiler and high-level synthesis languages, runtime, middleware and hardware.



LEGaTO System Overview

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 780681

LEGaTO Use Cases

Based on the energy-efficient hardware platform and the task-based programming environment developed, five LEGaTO use cases were significantly optimised:

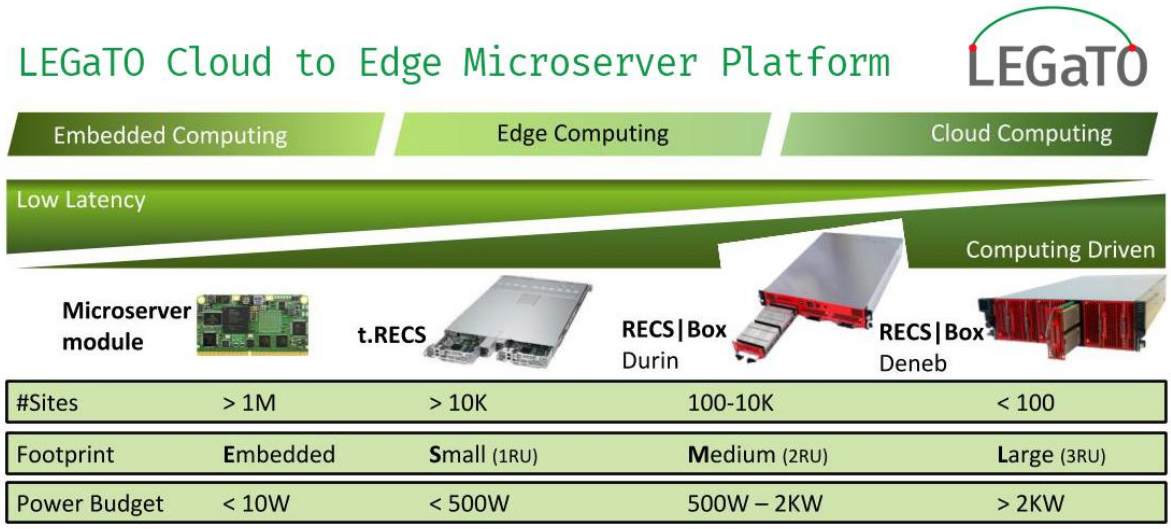
- The use of FPGAs resulted in a phenomenal 822x speedup in the **biomarker discovery use case**, which enables a new world of biomarker analysis.
- The use of shared-memory programming style on distributed GPUs led to 10x energy savings in the **smart home use case**, the SmartMirror.
- The **smart city use case** on operational urban pollutant dispersion modelling had a 7x gain in energy efficiency thanks to the use of FPGAs.
- Up to 16x gain in energy efficiency and performance was achieved in the **machine learning use case**, devoted to automated driving and graphics rendering, using the EmbeDl optimizer. This use case led to the creation of the spin-off EmbeDL, which improves energy efficiency and execution time in deep learning (DL) inference optimization tools.
- The **Secure IoT Gateway** was vital to simplify the complexity of communication of local devices to a network, and it supported the above mentioned use cases to achieve their goals by reducing the complexity of security.

LEGaTO Software Integration

The various elements of the software toolset have been integrated together to provide a unified look and feel that facilitates the porting of future use cases to the energy-efficient LEGaTO hardware/software platform.

LEGaTO Cloud to Edge Microserver Platform

With regard to the work on hardware, a LEGaTO Cloud to Edge Microserver Platform was developed, which covers most of the domains from cloud, edge and embedded computing by using a microserver architecture and a scalable system. It includes the LEGaTO Edge Server, which was completely designed and built in the project and focuses on edge and embedded applications.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 780681

LEGaTO influences European research and industry

The outcomes of the project have been very influential in the European research environment, as well as industry. Most of the LEGaTO components raised their Technology Readiness Levels (TRL) from concept to demonstrator moving closer to market, and some of them even became improved products or services offered commercially by LEGaTO's industrial partners.

Three upcoming European projects will continue the development of the results achieved in the LEGaTO project:

- LV-EmbeDL, a partnership between BSC and EmbeDL funded by Tetramax, will implement and demonstrate the FPGA undervolting techniques developed in LEGaTO.
- eProcessor, coordinated by BSC and with other 3 LEGaTO partners in the consortium, will deliver the first completely open source European full stack ecosystem based on RISC-V technology.
- VEDLIoT (Very Efficient Deep Learning in IoT), which brings together 5 LEGaTO partners and is led by Bielefeld University, will develop an IoT platform that uses deep learning algorithms distributed throughout the IoT continuum to achieve higher performance and energy efficiency.

About LEGaTO

The LEGaTO (Low Energy Toolset for Heterogeneous Computing) project is funded by the European Commission with a budget of more than €5 million and will last 3 years from its beginning on 1 December 2017. The partners of the project are Barcelona Supercomputing Center (BSC, Spain), Universität Bielefeld (UNIBI, Germany), Université de Neuchatel (UNINE, Switzerland), Chalmers Tekniska Högskola AB (CHALMERS, Sweden), Machine Intelligence Sweden AB (MIS, Sweden), Technische Universität Dresden (TUD, Germany), Christmann Informationstechnik + Medien GmbH & Co. KG (CHR, Germany), Helmholtz-Zentrum für Infektionsforschung GmbH (HZI, Germany), TECHNION - Israel Institute of Technology (TECHNION, Israel), Maxeler Technologies Limited (MAXELER, United Kingdom).

Further information: http://www.legato-project.eu

Multimedia resources:	**More information**:
LEGaTO system overview image LEGaTO System Overview video LEGaTO Cloud to Edge Microserver Platform image LEGaTO Cloud to Edge Microserver Platform video	Esther Dorado LEGaTO dissemination esther.dorado@bsc.es

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 780681