VINEYARD
Versatile Integrated Accelerator-based Heterogeneous Data Centres

ACCELERATE BIG DATA CLOUD APPLICATIONS AND REDUCE THE ENERGY CONSUMPTION OF DATA CENTRES

VINEYARD is a European project funded by the Horizon 2020 Framework Programme. Coordinated by ICCS – Institute of Communication and Computer Systems, the project´s consortium is composed by 11 partners with multidisciplinary backgrounds that cover the whole value chain of data centre framework *(including: Data Centre end-user, Programming, System Software, Hardware Accelerators, System Vendor, Data Centre Vendor, Platform Operator).*

The main objectives of the project are:

- To build energy-efficient data centres based on novel programmable hardware accelerators *(namely Dataflow engines and FPGA-coupled servers)* that can speed-up cloud computing and data analytic applications.
- To develop a high-level programming framework for allowing end-users to seamlessly utilize these accelerators in heterogeneous computing systems by employing typical data-centre programming frameworks *(i.e. Spark).*
- To foster the establishment of an ecosystem that will empower open innovation based on hardware accelerators as data-centre plugins, thereby facilitating innovative enterprises to develop novel solutions using VINEYARD's leading edge developments.

The main advantage of the VINEYARD framework is to allow the data centre programmers to seamlessly utilize the performance of hardware accelerators by loading the required modules from a central repository of hardware modules. The hardware modules, hosted in repositories, will be in the form of pluggable modules that can be loaded on demand based on the application requirements.

VINEYARD project will not only develop energy-efficient servers, but also to demonstrate its advantages in real applications such as:

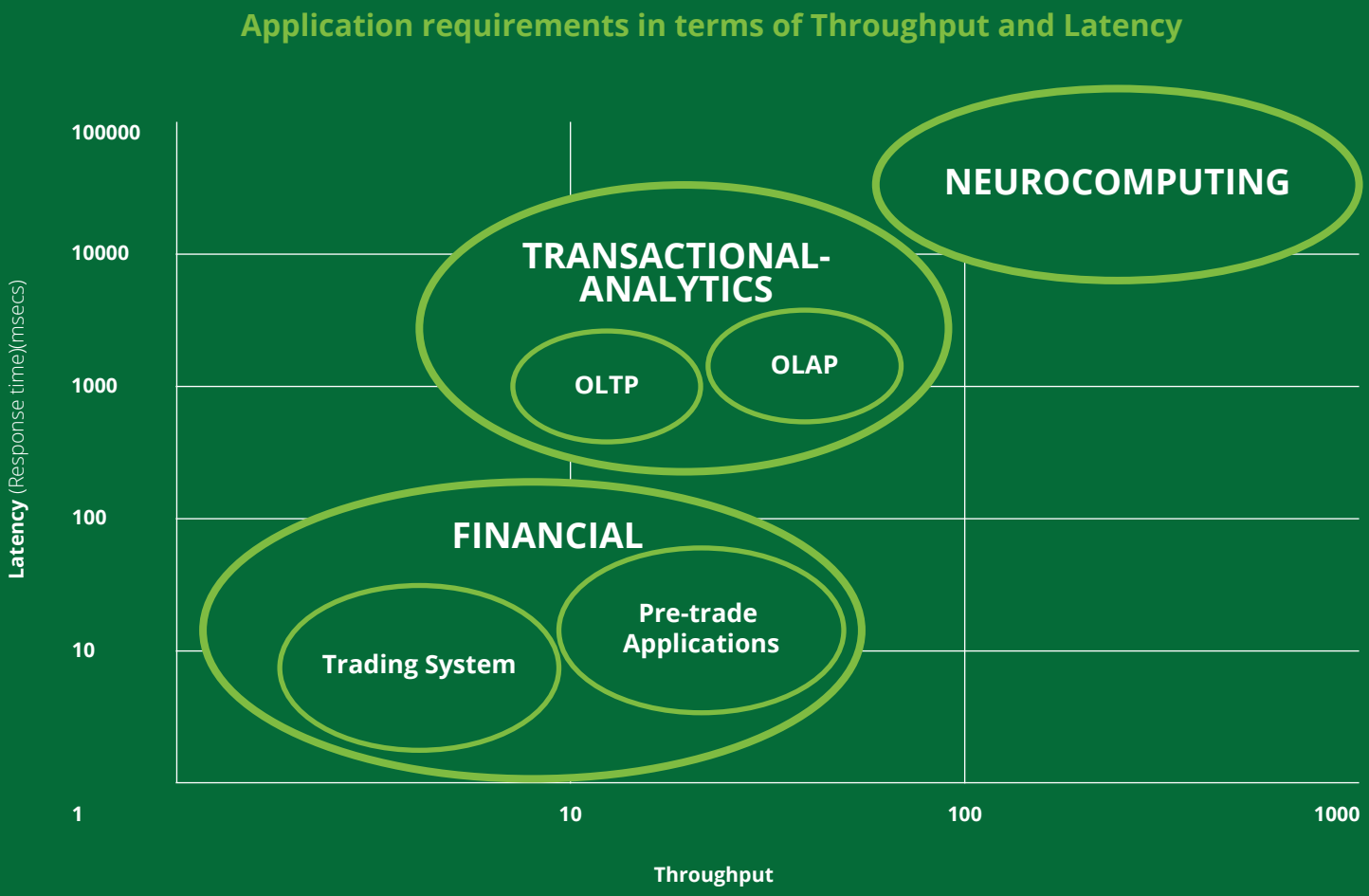
- **Computational neuroscience**, namely brain exploration through simulation of biologically accurate neuronal models
- **Financial applications**, like trading system operations and pre-trade risk management
- **Data analytics**, for instance on-line transaction processing benchmark and decision support benchmark

VINEYARD´S GROUNDWORK:
SCREENING THE APPLICATIONS REQUIREMENTS AND SPECIFICATIONS

One of the first tasks of the VINEYARD project, entitled "application requirements, specifications and profiling", has laid important foundation work for latter activities of VINEYARD project. This task has focused on identifying, organizing and exhaustively listing the application-side requirements *(and related metrics)* that are crucial for each of the considered VINEYARD use cases, namely the neurocomputing, financial, and data-management.

For this purpose, a basic taxonomy of datacentre applications has been implemented, where the requirements have been grouped in two major categories: Functional and QoS *(non-functional)* requirements. The three VINEYARD use cases *(neurocomputing, financial and data-management)* have been extended by cloud applications. All involved applications are presented in detail and their respective requirements are given as design objectives for VINEYARD.

An overview of the latency requirements for the various VINEYARD applications is presented below:



APPLICATION REQUIREMENTS OF THE VINEYARD USE-CASES

During this analysis, it was worth considering to capture the datacentre-side *(or infrastructure)* requirements, as it would be interesting to try to take also into account when (re-)deploying the applications in the VINEYARD datacentre paradigm. In so doing, VINEYARD could be among the first projects to provide solutions involving performance-aware and cost-aware application deployment in modern datacentres in the form of combined metrics.

Due to the above, the work on screening requirements was extended to also include infrastructure-side requirements, such as resource utilization. Involving both types of requirements *(application-side and infrastructure-side)* is an intriguing and challenging endeavour since many of these serve opposing objectives. The main challenge we face today is to achieve a balance between the two sides: to operate infrastructure at high utilization without damaging user experience. Combined metrics are one of the Holy Grails currently sought for by the industry which are not used today.
Thus, involving both types of requirements and merging them in practical, combined metrics is an interesting conclusion of this task.

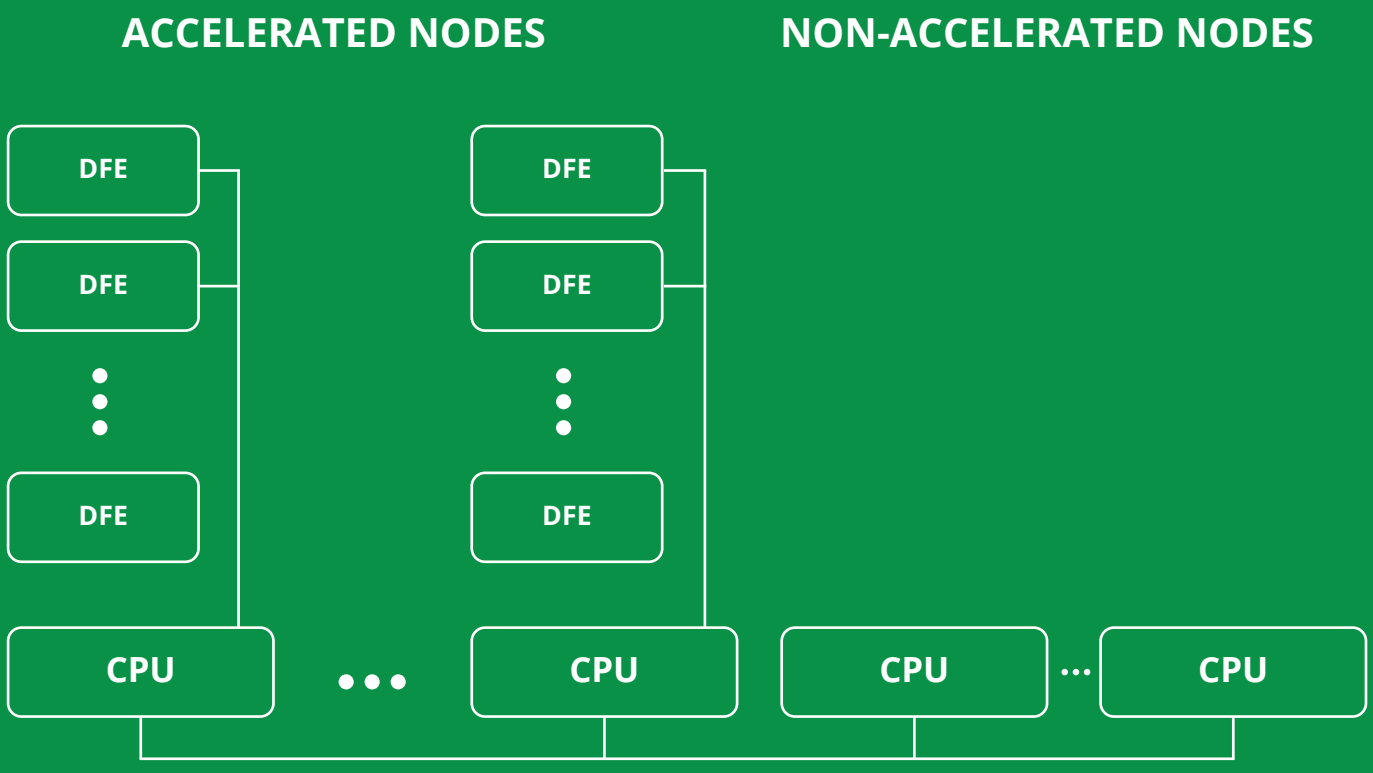
The main results from this analysis and the agreement on a common set of requirements *(both application and infrastructure side)* are duly presented in a public report, that will be shortly available at the VINEYARD website.

ACCELERATING SPARK APPLICATIONS WITH MAXELER DATAFLOW ENGINES

We have investigated the acceleration of compute-intensive data centre applications using Field-Programmable Gate Arrays (FPGAs), in particular those programmed in a "soft" manner using the Maxeler DataFlow Language. We assume a data centre containing many nodes with general-purpose processors, some of which are extended with a number of Maxeler DataFlow Engines (DFEs) (See figure below). These systems are programmed using a hybrid programming model: a data centre programming system such as Hadoop or Spark to manage data and computation at the node level, and the Maxeler DataFlow Language to manage the DFEs. DFEs are virtualized and offered "as a service".

Key challenges to address include the selection of tasks to accelerate and scheduling these tasks on DFEs. Moreover, data management and data representation in the Java Virtual Machine (JVM) must be optimized in order to streamline the data sharing between the JVM and the FPGA. Our preliminary results indicate good scalability across data set sizes. For instance, linear correlation, an algorithm with very low computation to communication ratio, is accelerated by up to 138-fold, depending on the data set size, when migrating the key computation from Spark to the Maxeler DFE.

Our results show that acceleration of Spark applications using Maxeler DFEs is promising. Throughout VINEYARD project, we will further analyse and reduce overheads incurred by data sharing between Spark and accelerators. We will also extend the programming environment and runtime support to ease the programming effort and to make virtualization of accelerators more efficient.



DATA CENTRE ORGANIZATION WITH FEW ACCELERATED NODES

NEWS

PARTICIPATION IN THE COLLABORATION WORKSHOP **"ADVANCED COMPUTING AND CYBER-PHYSICAL SYSTEMS 2016"** *(14 June 2015 – Brussels)*

On June 14th, the coordinators of VINEYARD project, Christoforos Kachris and Dimitrios Soudris from ICCS/NTUA, participated in the collaboration workshop Advanced Computing and Cyber-Physical Systems 2016 co-organised by the European Commission DG CONNECT and HiPEAC.

This invitation-only workshop brought together projects focused on cyber-physical systems, advanced computing and mixed-criticality systems funded by the European Commission under the FP7 ICT Call 10 (2013), Horizon2020 ICT Call 1 (2014) and Call 4 (2015). The main objectives were to foster networking and identify synergies, to assess progress and share examples of best practice and to explore future plans for digital technologies in Europe.

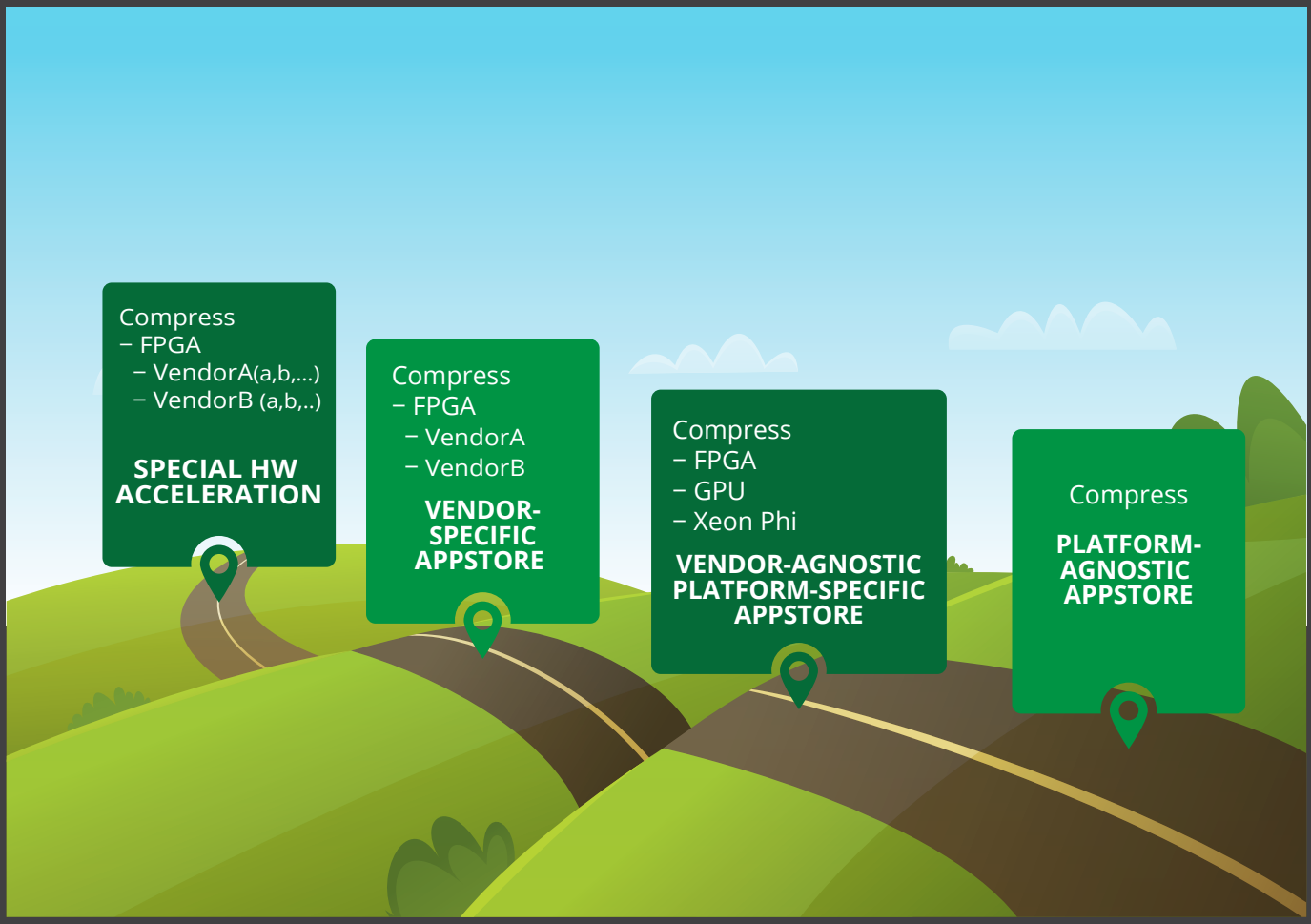
During this workshop, the project coordinator of VINEYARD, ICCS, presented the main goals and the vision of the project. Specifically, presented their approach towards energy-efficient heterogeneous data centres based on hardware accelerators that can provide higher speedups while reducing the total energy consumption. In this workshop they also had the chance to discuss with other projects working on the domain of heteregeneous data centres like dRedBox, Nanostreams and Ecoscale.

PARTICIPATION IN THE **HIPEAC ROADMAP WORKSHOP** *(27 June 2016 – Brussels)*

On June 27th, the VINEYARD coordinators, ICCS participated in the HiPEAC Roadmap session that took place in Brussels. The workshop was organized with the purpose of shaping the next version of the HiPEAC vision for computer architecture and embedded systems.

During this workshop, ICCS presented the main goal and the vision of the VINEYARD project. Specifically, it presented their view on the future of hardware accelerators in the data centres and the notion of an Application Store (Android-like Store) in which 3rd party hardware developers can upload their designs in the form of IP blocks, similarly to the domain of mobile applications. Cloud tenants, can then seamlessly utilize these hardware accelerators by deploying automatically the hardware accelerators in the heterogeneous data centre infrastructure.

ICCS also presented the roadmap towards the efficient deployment of hardware accelerators in the data centres in which the Application Store will evolve from Vendor-specific, Device-specific libraries to vendor-agnostic and finally platform-agnostic libraries.



PARTICIPATION AT **FPL2016** – RESULTS OF THE SURVEY ON RECONFIGURABLE ACCELERATORS FOR CLOUD COMPUTING *(1 September 2016 – Laussane)*

On September 1st, the coordinators of VINEYARD project, Christoforos Kachris and Dimitrios Soudris from ICCS/NTUA, presented the paper "A Survey on Reconfigurable Accelerators for Cloud Computing" at the 26th International Conference, Field-Programmable Logic and Applications "FPL 2016", that took place in Laussane, Switzerland.
In this work, VINEYARD coordinators presented a thorough survey of the frameworks for the efficient utilization of the FPGAs in the data centres. Furthermore, they presented the hardware accelerators that have been implemented for the most widely used cloud computing applications. The survey also provided a qualitative categorization and comparison of the proposed schemes in terms of speedup and energy efficiency based on category, the type of applications, the communication interface and the design method.

Overall, it is shown that reconfigurable computing (FPGAs) can provide up to 31x speedup compared to the typical processors and up to 33x better energy consumption on several cloud computing applications.

EVENTS

WORKSHOP ENeSCE 2017

(23 January 2017 - Stockholm)

The Workshop ENeSCE 2017 "Energy-efficient Servers for Cloud and Edge Computing 2017" will take place on the 23 of January 2017 in Stockholm, Sweden, co-located with HiPEAC 2017 Conference.
This workshop is organized by 4 EC-funded projects working on the area of energy-efficient servers, namely VINEYARD, dRedBox, M2DC and Uniserver. The workshop aims to present the most recent work on next generation energy efficient servers and foster the interaction between the universities, research centres and industry that work on this area.
The call for papers is open until November 4, 2016 (AOE)

More information at
conferences.microlab.ntua.gr/enesce2017/

HIPEAC CONFERENCE

(23-25 January 2017 – Stockholm)

The 12th HiPEAC Conference will take place in Stockholm, Sweden from the 23rd to the 25th of January 2017.

HiPEAC Conference is the premier European forum for experts in computer architecture, programming models, compilers and operating systems for embedded and general-purpose systems. Associated workshops, tutorials, special sessions, several large poster session and an industrial exhibition will run in parallel with the conference.

More information at
www.hipeac.net/2017/stockholm/

PROJECT INFORMATION

VINEYARD – VERSATILE INTEGRATED ACCELERATOR-BASED HETEROGENEOUS DATA CENTRES

Start date February 1st, 2016

Duration 36 months

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