SPARCITY

NEWSLETTER

Issue 2 | January 2023

KOÇ UNIVERSITY · Sabancı Üniversitesi · inesc id lisboa · [simula . research laboratory] · LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN · GRAPHCORE

In this issue:

EDITORIAL

Dear readers,

Launched in April 2021, this 3-year project is funded by the European High Performance Computing Joint Undertaking (EuroHPC JU) under the 2019 call of Extreme Scale Computing and Data Driven Technologies for research and innovation actions.

The SparCity project aims at creating a supercomputing framework that is providing efficient algorithms and coeherent tools specifically designed for maximizing the performance and energy efficiency of sparse computations on emerging HPC systems, while also opening up new usage areas for sparse computations in data analytics and deep learning.

SparCity delivers a coherent collection of innovative algorithms and tools for enabling both high efficiency of sparse computations on emerging hardware platforms.

The SparCity Coordination,

Didem Unat

In-person Meeting | September 1-3, 2022 (Istanbul, Turkey)

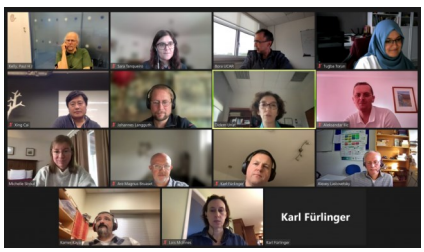
PAST EVENTS

☒ First EuroHPC19 Workshop to Seed and Foster Collaborations Across Europe | September 19-20, 2022

The first EuroHPC19 Workshop was held in Madrid with members of the other 9 projects funded under our EuroHPC Joint Undertaking to seed and foster collaborations across Europe. Dr Xing Cai presented the SparCity work: "Performance modeling and analysis of Sparse Computation Workloads."

☒ Meeting with Advisory Board | October 14, 2022

We had our first meeting with the Advisory Board. It was a very efficient and successful session to reflect on the project's overall status and discuss the main achievements accomplished so far.



☒ Administrative Meeting | October 21, 2022

This meeting was held to reflect on the feedbacks of the Advisory Board and prepare the Review Meeting with the European Commission.

☒ Administrative Meeting | October 28, 2022

PIs and administrative staff met to complete and submit the First Periodic Report.

☒ Review Meeting | November 10, 2022

SparCity WP leaders met with 3 external evaluators and the Project Officers from the European Commission, in Luxembourg, to overview the first 18 months of the project.

☒ IEEE 34th International Symposium on Computer Architecture and High Performance Computing (SBAC-PAD'22) |November 2-4, 2022

SparCity members were present at the SBAC-PAD'22 in Bordeaux, France. Erhan Tezcan, from Koç University, won the SBAC-PAD 2022 Best Paper Award with his Mixed and Multi-Precision SpMV work.

☒ ParCoreLab Seminars | December 8, 2022

Dr James Trotter from Simula presented his work on "Multi-GPU Code Generation" at the ParCoreLab Seminars.

☒ MLOpt 2023 Workshop, HiPEAC | January 16, 2023

The MLOpt 2023 Workshop was held at HiPEAC 2023 in Toulouse. This workshop was organized by SparCity (Dr Karl Fuerlinger, LMU Munich, Germany) and DComEX (Dr George Stavroulakis, NTUA, Greece) and had around 20 participants. It was a great opportunity to discuss the usage of ML techniques on high-performance and parallel computing platforms. Dr Johannes Langguth from Simula presented the work developed on "Machine Learning Approaches for Sparse Matrix Vector Optimization", Eren Yenigül from Koç University was also presente with "Efficient extraction of Sparse Tensor Features" and Miguel Graça from INESC-ID with "On Efficient Deep Learning for Epistasis Detection".

☒ EuroHPC Workshop: Shaping Europe's HPC landscape | January 17, 2022

SparCity members attended this workshop at HiPEAC 2023 Conference.

☒ Technical Meetings | Every 2 weeks

This meetings have been important to present and discuss the developed work in each work package.

COMMUNICATION, DISSEMINATION & OUTREACH

♦ **European Girls' Olympiad in Informatics (EGOI)**
October 16, 2022, Antalya, Turkey

Didem Unat, the SparCity Coordinator, delivered a keynote speech at the opening ceremony of the 2nd European Girls' Olympiad in Informatics (EGOI), hosted by TCSanayi and TÜBİTAK in Antalya! Let's build a future that ensures girls have the same opportunities as boys.

♦ **Mentor-protégé mixer at SC 2022**
November 14, 2022, Dallas, Texas

Didem Unat was invited to be a mentor and speak with a small group of mentees (Postdocs, PhD and master students and some new graduates) to answer their questions and establish a connection Mentees rotate the tables having an opportunity to talk to several mentors during a specified amount of time asking questions and trying to establish a connection.

♦ **#MeetTheTeam and #CodeVideos Series**

On December 2, we launched the #MeetTheTeam series on SparCity YouTube channel with Didem Unat presenting the project. Two weeks later, we release the first #CodeVideo about Mixed Precision.
On January 13, we published a new video with Amro Aljundi, from Sabanci University.
Two videos will be released every month where you can learn more about a different team member and the work developed within SparCity.

AWARDS

♦ Erhan Tezcan, our team member from Koç University, won the SBAC-PAD 2022 Best Paper Award with his Mixed and Multi-Precision SpMV work.

♦ Didem Unat received the 2021 ACM SIGHPC Emerging Woman Leader in Technical Computing Award!

♦ Didem Unat was awarded with the 2021 Scientist of the Year Award by Bilim Kahramanları Derneği.

PUBLICATIONS

♦ Erhan Tezcan, Tugba Torun, Fahrican Koşar, Kamer Kaya, and Didem Unat (2022). Mixed and Multi-Precision SpMV for GPUs with Row-wise Precision Selection. IEEE 34th International Symposium on Computer Architecture and High Performance Computing (SBAC-PAD'22).
Doi:10.1109/SBAC-PAD55451.2022.00014.

Congratulations to our students for their Msc. Thesis Defense!

♦ Arda Şener, “Generating landmark labels for short distance queries in a distributed setting”.
Date: December 19, 2022.

♦ Fatih Taşyaran, “SuperTwin: Digital Twins for high-performance computing clusters”.
Date: December 29, 2022.

RESOURCES

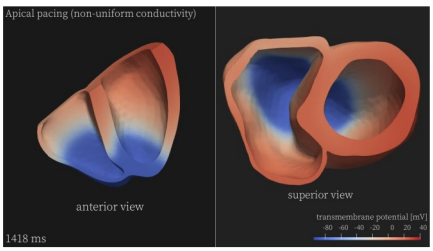
One of the main aims of SparCity is to validate the developed methodology and tools for use cases across different application areas and modelling paradigms.

Modelling the Heart

About 50% of deaths by cardiovascular diseases are caused by cardiac arrythmia, where the synchronisation of the electrical signals that make the heart pump blood is disturbed. Detailed computer models are used to better understand the electrophysiology of the heart and how this complicated system is affected by disease. A computational cardiac model consists of a linear, parabolic partial differential equation (PDE) modelling the anisotropic diffusion of the electrical potential in the cardiac tissue, and a set of nonlinear ordinary differential equations (ODEs) modelling the electrochemical processes at cellular and subcellular levels that cause the time-varying electrical signal driving the heart beats. These differential equations are solved across a discretised heart geometry represented as a volumetric mesh, preferably originating from patient-specific imagery.

The discretised PDE leads to a large system of algebraic equations (1-1,000 million) and uknowns - very sparse. These equations are usually solved iteratively by Krylov subspace methods, which involve one or more sparse matric-vector multiplications in each iteration.

Using the methods and tools developed in SparCity, a monodomain cardiac model based on realistic heart geometries has been substantially improved with respect to computing time by optimising the sparsity pattern in a computationally favourable way through use of reordering algorithms. Simula has been able to implement the cardiac model on the Graphcore IPU, using the low-level programming interface Poplar, delivering performance that is on par with state-of-the-art GPUs. Efficient use of the IPU for the cardiac use case demonstrates a promising potential for use of such hardware to solve PDE-based problems.



Code Video

High-order Epistasis Detection

Certain gene mutations depend on whether other modifier genes have mutated or not. This interaction between mutations is referred to as epistasis and may explain susceptibility to certain diseases and can play an important role in personalised treatment and prevention of disease. There are several computational methods for the detection of high-order epistasis (when involves more than two mutations), which can be seen as a large-scale combinatorial problem with a vast search space. The corresponding search algorithms represent highly data-parallel workloads, since the same operations are performed for each combination of genetic markers.

Our team has pursued third- and fourth-order epistasis detection using algorithms that exploit the sparsity of the problem, particularly in connection to repeated sparse matrix-matrix multiplications.

Our study has been conducted across a wide range of different CPU and GPU microarchitectures from Intel, AMD and NVIDIA. In the context of CPU implementations, the code optimisations have been guided by extended cache-aware roofline models developed in the SparCity project. On the average, our CPU implementations outperform the previous state-of-the-art works by a factor of 7.3, while our GPU implementations using the SYCL framework achieve a speedup factor of 2.8. Experiments with different matrix reordering techniques have shown performance improvement of up to 15% on current CPU micro-architectures.

The epistasis detection algorithms are generally performing better on GPUs than CPUs and FPGAs, mainly due to the very efficient use of tensor core operations. For the approach proposed in the SparCity project, this becomes even more evident. When comparing to a previous state-of-the-art implementation on NVIDIA Titan RTX GPUs, the SparCity implementation achieves a speedup of 12 times. Accelerating this further by using the NVIDIA A100 GPU, the SparCity implementation runs 370 times faster than the previous state-of-the-art implementation on the RTX. Initial studies of implementations for the Graph IPU have also been conducted with promising results.

Code Video

UPCOMING EVENTS

♦ ISC 2023 Conference,
Hamburg, Germany
May 21-25, 2023

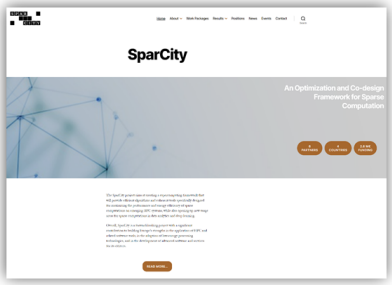
♦ SparCity Workshop (ISC 2023),
Hamburg, Germany
May 25, 2023, TBC

♦In-person Meeting,
Lisbon, Portugal
June 15-16, 2023

♦EuroPar 23
Limassol, Cyprus
August 28 - September 1, 2023

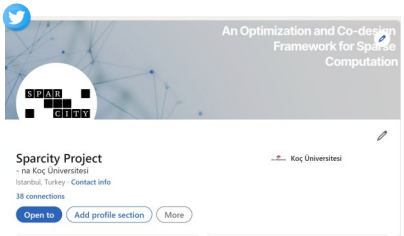
♦SC 23,
Denver, Colorado
November 12 - 17, 2023

WEBSITE

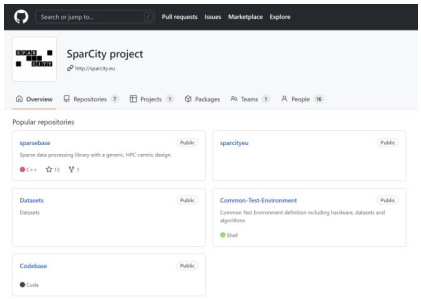


https://sparcity.eu

SOCIAL MEDIA



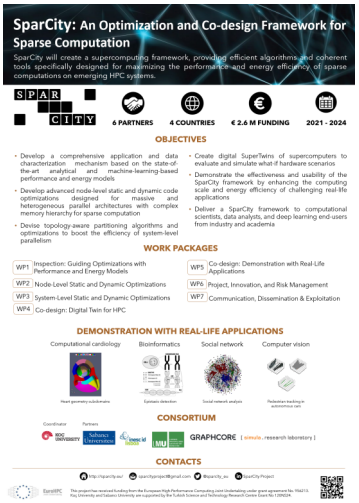
REPOSITORY

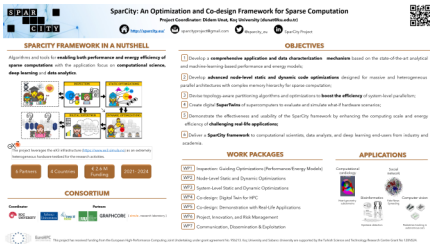


https://github.com/sparcityeu

PROMOTIONAL MATERIALS

SparCity Posters





MORE INFORMATION

https://sparcity.eu
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This project has received funding from the European High-Performance Computing Joint Undertaking under grant agreement No 956213.

Koç University and Sabancı University are supported by the Turkish Science and Technology Research Centre Grant No 120N003 and 220N254, respectively.

Simula and Graphcore are supported by the Research Council of Norway. Ludwig-Maximilians-Universität München (LMU) is supported by the German national Funding agency (BMBF). INESC-ID is supported by Fundação para a Ciência e a Tecnologia (FCT).