IEEE HPEC 2023

Spla: Generalized Sparse Linear Algebra Library With Vendor-Agnostic GPUs Acceleration

Egor Orachev[1] Semyon Grigorev[1]
egor.orachev@gmail.com s.v.grigoriev@spbu.ru,
[1] *St. Petersburg University, Russia*

Problem Statement

Scalable high-performance graph analysis is a challenge. GraphBLAS standard attempts to solve this challenge using sparse linear algebra operations. The full GPU-based implementation of this standard is still missing. Existing works are focused on Nvidia Cuda platform only, what limits their potability.

Is it possible to implement portable GPU-based library with generalized sparse linear algebra operations for graph analysis?

Results

Spla, the generalized sparse linear algebra library with vendor-agnostic GPUs accelerated computations.

- Proven **portability** of the OpenCL-based solution.
- Demonstrated **competitive** performance.
- Had acceptable **scalability** on devices of different GPUs vendors.
- Published **package** for python users.

Future Research

- Adaptive workload balance for better GPU's waves utilization.
- Performance tuning of auxiliary utilities, such as sorting, reduction, etc.
- New operations variations, such as SpGEMM, SpMM, etc.
- Graph data from RAM to VRAM streaming.
- Sclalability to multiple GPUs.

Motivating Example

```python
from pyspla import *

def bfs(s: int, A: Matrix):
    v = Vector(A.n_rows, INT)
    front = Vector.from_lists([s], [1], A.n_rows, INT)
    front_size = 1
    depth = Scalar(INT, 0)

    while front_size > 0:
        depth += 1
        v.assign(front, depth, op_assign=INT.SECOND, op_select=INT.NQZERO)
        front = front.vxm(v, A, op_mult=INT.LAND, op_add=INT.LOR, op_select=INT.EQZERO)
        front_size = front.reduce(op_reduce=INT.PLUS).get()

    return v, depth.get()
```

Push-only BFS implementation with out of the box **GPUs acceleration** using **pyspla** package API available at PyPI.

Implementation

Spla implemented using the C++17 language and vendor-agnostic OpenCL 1.2 for GPU specific computations. General optimizations:

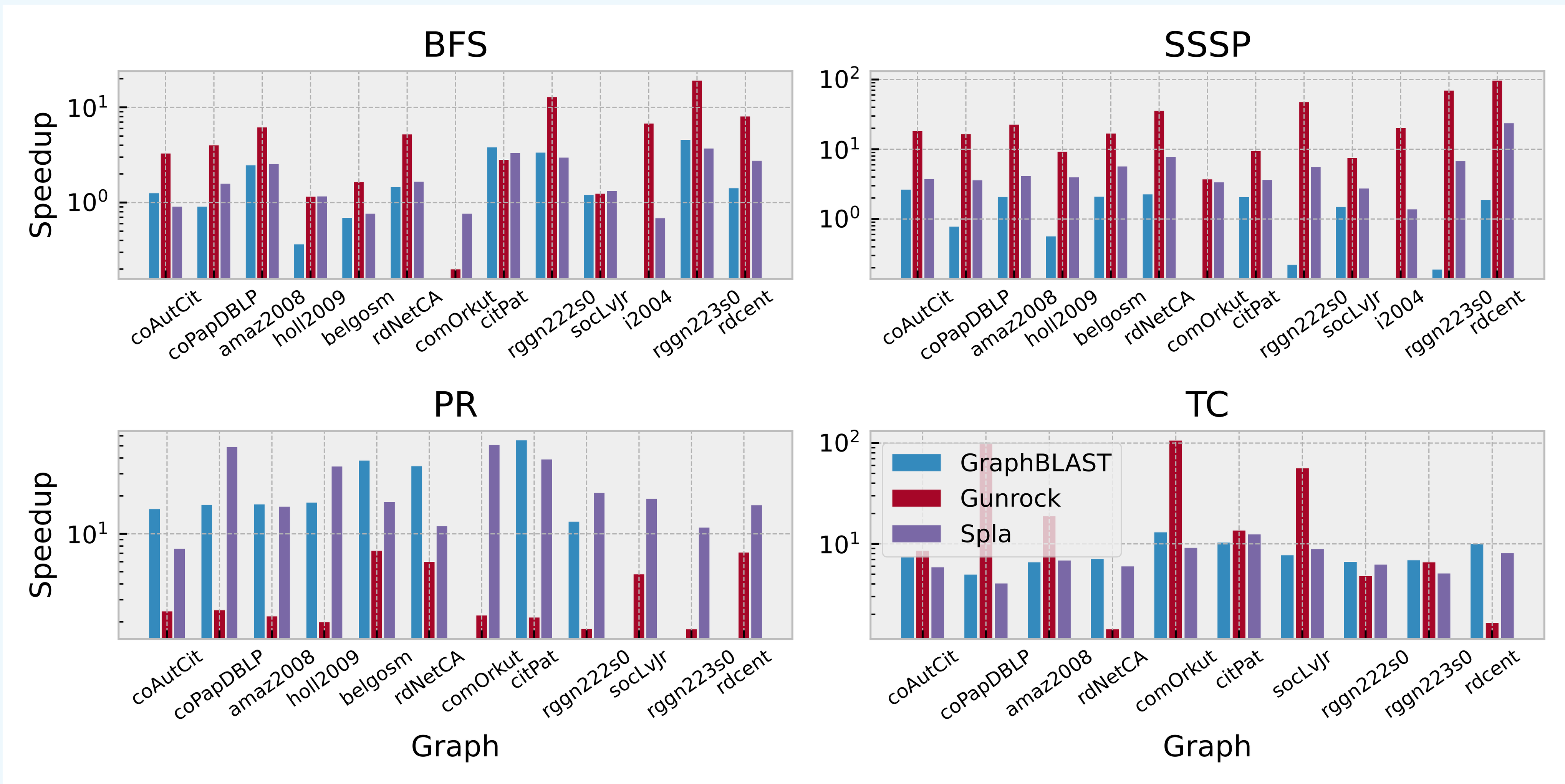
- **K-way merge-based** *vxm* operation [4].
- **Push-pull** and **early-out** [5].
- **Masking** of reached vertices [2].
- **Sparse-dense** storage switch [2].

OpenCL Specifics

Auxiliary functionality and optimizations to reduce mostly OpenCL CPU-side driver overhead:

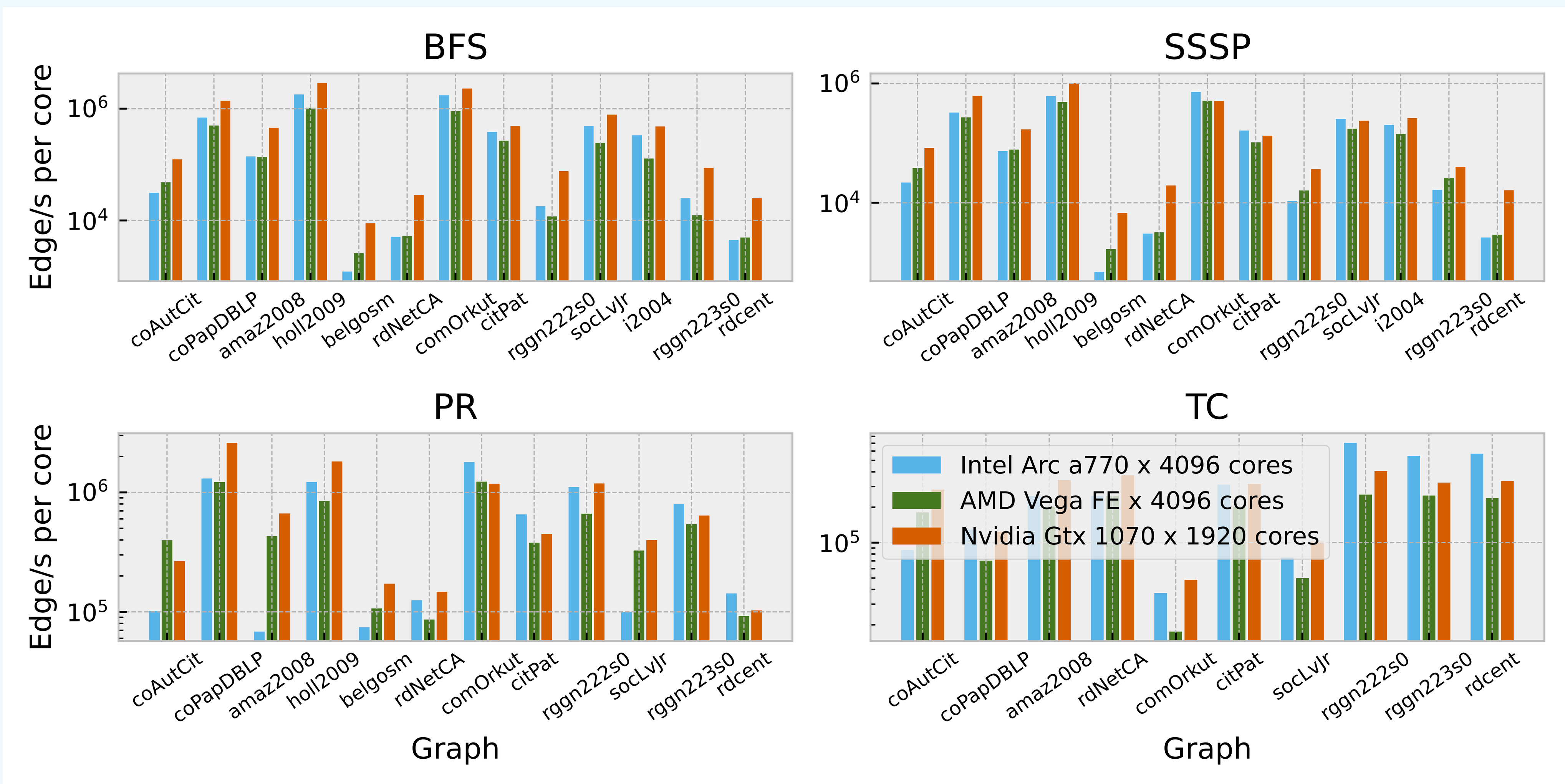
- Run-time compiled **kernels cache** with a robin hood hash map for fast look-ups.
- In-place **unique kernel key** string constriction.
- Kernel code compilation with **user-defined** functions using simple text preprocessing.
- **Custom linear allocator** based on sub-buffer mechanism for temporary small ($\leq 1MiB$) allocations.
- **Custom auxiliary** operations, such as *sort*, *reduce*, *scan*.

Evaluation: Performance on a Nvidia GPU



Tools: Gunrock [1], GraphBLAST [2], Spla and LaGraph [3] as a baseline.
Configuration: Ubuntu 20.04, 3.40Hz Intel Core i7-6700 4-core CPU, DDR4 64Gb RAM, Nvidia GeForce GTX 1070 dedicated GPU with 8Gb on-board VRAM.

Evaluation: Scalability on different GPUs



Configuration: Ubuntu 20.04, 3.40Hz Intel Core i7-6700 4-core CPU, DDR4 64Gb RAM, Nvidia GeForce GTX 1070 dedicated GPU with 8Gb VRAM, Intel Arc A770 flux dedicated GPU with 8GB VRAM and or AMD Radeon Vega Frontier Edition dedicated GPU with 16GB VRAM.

Contact Us

Our team:

- Semyon Grigorev: s.v.grigoriev@spbu.ru
- Egor Orachev: egor.orachev@gmail.com

Acknowledgments

We would like to thank Huawei Technologies Co., Ltd for supporting this research. We are also grateful to our team and reviewers.

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