Approaches for Improving Graph Coloring in Large Real-World Graphs

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Introduction

- Graph coloring is a combinatorial optimization problem that involves partitioning a graph in a minimum number of independent sets to identify which sets of tasks can be performed in parallel.
- Reducing the number of colors used can significantly make parallel platforms more efficient as the number of synchronization points is decreased.
- Applications of graph coloring appear in several places like automatic differentiation, printed circuit testing, frequency assignment, register allocation, parallel numerical computation, and optimization areas.

Previous and Our Work

- Many commonly known vertex visit orderings have been proposed in literature. Commonly known vertex visit orderings are Largest First, Smallest Last. Saturation Degree and Incidence Degree Orderings. [2]
- We have tried to find orderings based on core, truss and nucleus decompositions (generalization of k-core and k-truss decomposition) to come up with better coloring of vertices.

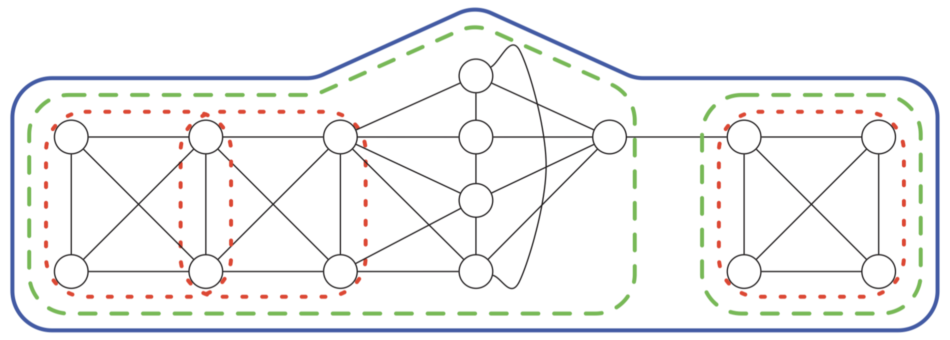

Figure 1: Comparison of the subgraphs reported by (1,2), (2,3) and (3,4) nucleus decompositions. [1]

- Informally, an (r, s)-nucleus, for fixed positive integer $r \leq s$, is a maximal sub-graph where every r-clique (i.e., complete graph of r nodes) in it is part of many s-cliques.
- Used datasets from social (hamster, reed, simmons), collaboration (jazz, erdos), interaction (pgp), internet topology (caida), and infrastructure (powergrid) network along with application areas in automotive industry, linear car analysis, finite element and structural engineering (auto, bmw3_2, pwtk, hood).

Vertex Visit Ordering Analysis

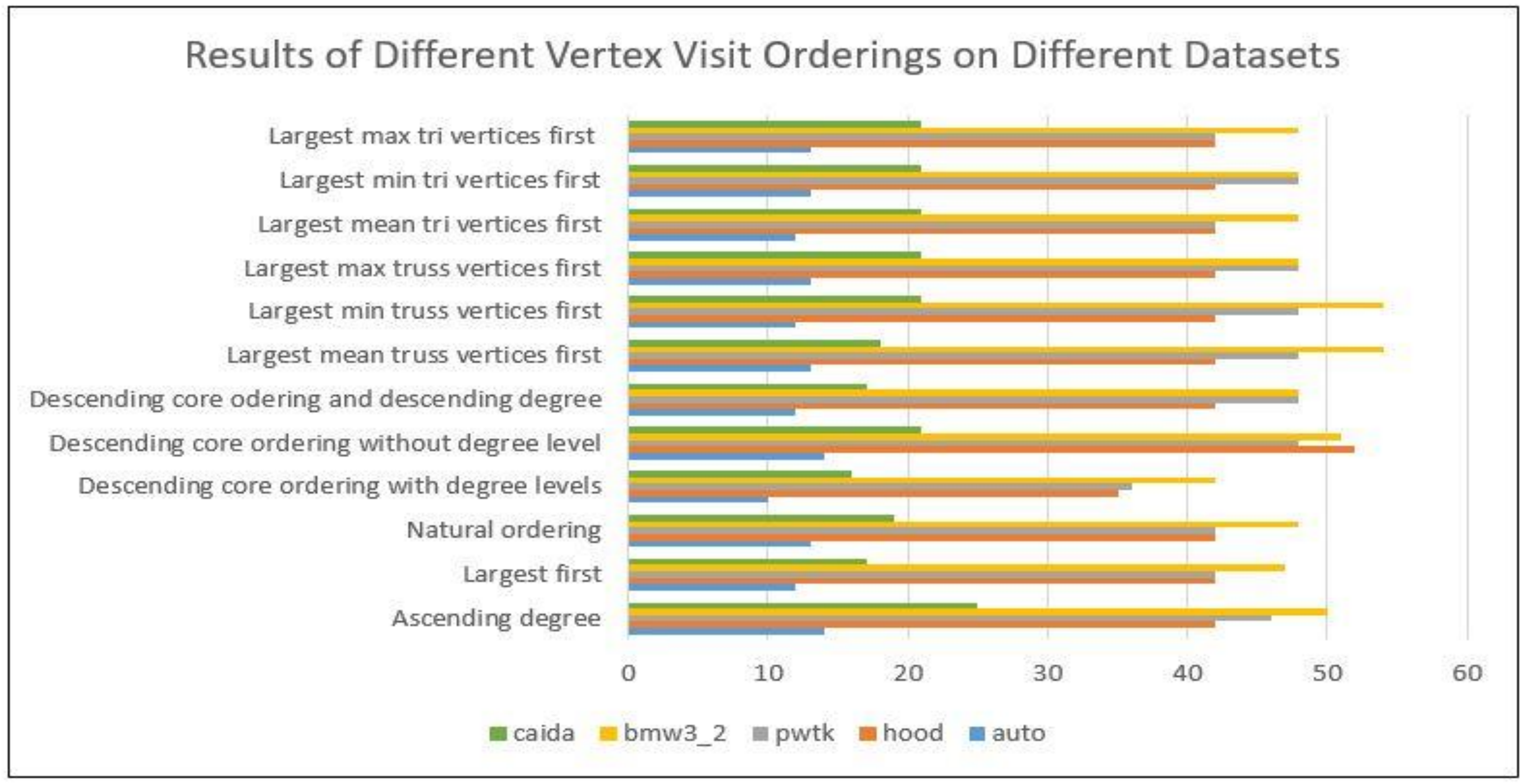

Figure 2 : Performance with different vertex visit Orderings

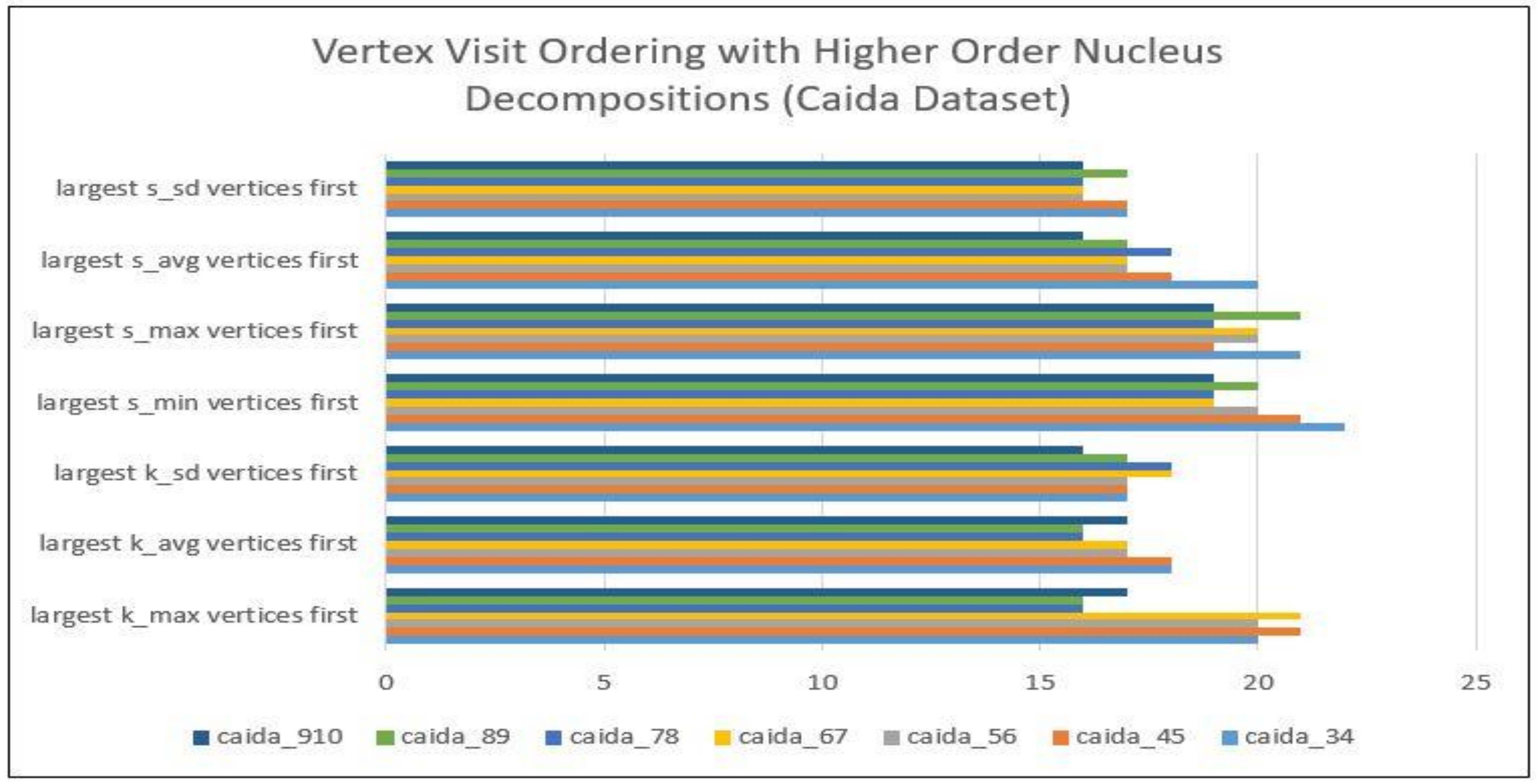

Figure 3 : Performance with different vertex visit orderings on higher order nucleus decompositions

Results and Conclusion

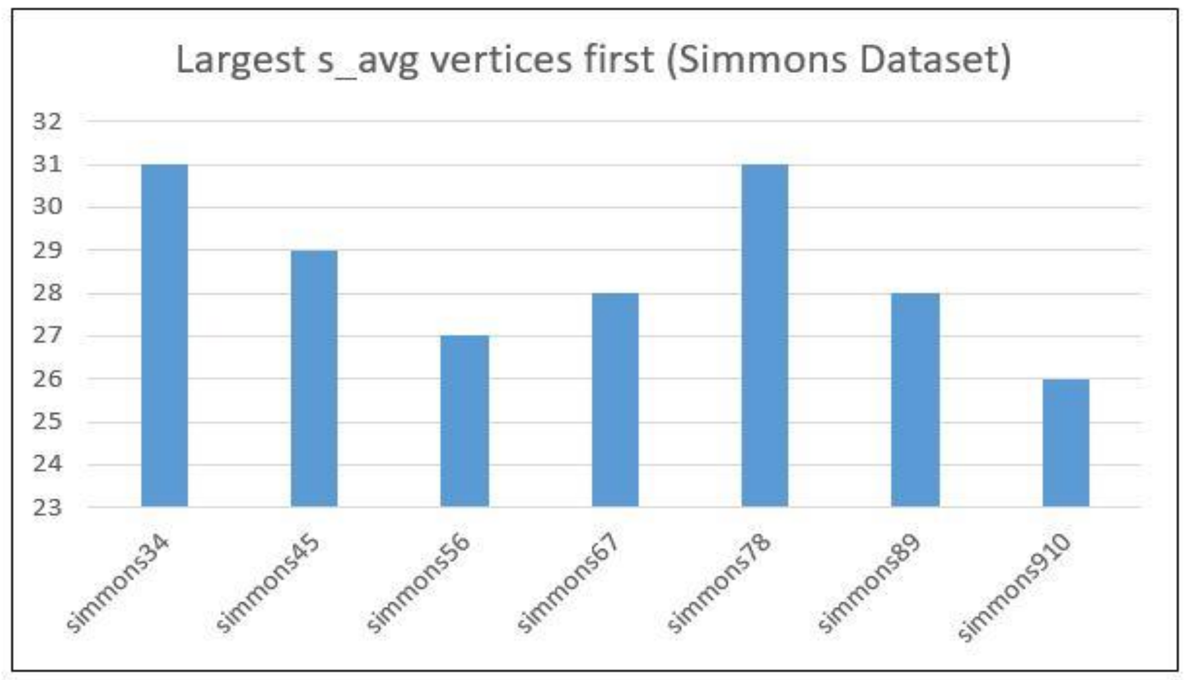

Figure 4 : Vertex ordering based on based on s value

- 43 different Vertex Ordering were run on 15 different graph datasets with varying number of vertices and edges from different sources.
- Coloring the vertices according to descending core ordering with degree levels almost always produced the best results.
- Only Simmons Dataset showed best results with largest first ordering.
- Ordering vertices according to largest standard deviation of s value in (9,10) nucleus decompositions shared the best results descending core ordering with degree levels (except reed dataset).
- For a particular type of vertex visit ordering, (9,10) nucleus decompositions almost always produced better results than (3,4) nucleus decompositions.

References

1. Sarıyüce, Ahmet Erdem, et al. "Nucleus decompositions for identifying hierarchy of dense subgraphs." ACM Transactions on the Web (TWEB) 11.3 (2017): 16.
2. Sarıyüce, Ahmet Erdem, Erik Saule, and Ümit V. Çatalyürek. "Improving graph coloring on distributed-memory parallel computers." *2011 18th International Conference on High Performance Computing*. IEEE, 2011.