Referee Report

Paper Number:
Reviewer's Name: Jesse Bannon
Name of Paper: Machine and Application Aware Partitioning for Adaptive Mesh Refinement Applications
Author(s): Milinda Fernando, Dmitry Duplyakin, Hari Sundar

Section I. Overview

A. Reader Interest

1. Which category describes this manuscript?

(x) Practice / Application / Case Study / Experience Report
( ) Research / Technology
( ) Survey / Tutorial / How-To

2. How relevant is this manuscript to the readers of this periodical? Please explain your rating under IIIA.

( ) Very Relevant
( ) Relevant
(x) Interesting - but not very relevant
( ) Irrelevant

B. Content

1. Please explain how this manuscript advances this field of research and / or contributes something new to the literature. Please explain your answer under IIIA. Public Comments.

2. Is the manuscript technically sound? Please explain your answer under IIIA. Public Comments.

( ) Yes
(x) Appears to be - but didn't check completely
( ) Partially
( ) No

C. Presentation

1. Are the title, abstract, and keywords appropriate? Please explain your answer under IIIA. Public Comments.

(x) Yes
( ) No

2. Does the manuscript contain sufficient and appropriate references? Please explain your answer under IIIA.

(x) References are sufficient and appropriate
( ) Important references are missing; more references are needed
( ) Number of references are excessive

3. Does the introduction state the objectives of the manuscript in terms that encourage the reader to read on? Please explain your answer under IIIA. Public Comments.

(x) Yes
( ) Could be improved
( ) No

4. How would you rate the organization of the manuscript? Is it focused? Is the length appropriate for the topic? Please explain your answer under IIIA. Public Comments.

(x) Satisfactory
( ) Could be improved
( ) Poor

5. Please rate and comment on the readability of this manuscript. Please explain your answer under IIIA.

(x) Easy to read
( ) Readable - but requires some effort to understand
( ) Difficult to read and understand
( ) Unreadable

Section II. Summary and Recommendation

A. Evaluation

Please rate the manuscript. Please explain your answer under IIIA. Public Comments.

( ) Award Quality
( ) Excellent
(x) Good
( ) Fair
( ) Poor

B. Recommendation

Please make your recommendation. Please explain your answer under IIIA. Public Comments.

(x) Accept with no changes
( ) Author should prepare a minor revision
( ) Author should prepare a major revision for a second review
( ) Reject

Section III. Detailed Comments

A. Public Comments (these will be made available to the author)

Explanation for the Recommendation

This research provided a simple yet informative solution to achieve a performance gain for adaptive mesh refinement (AMR) applications. The goals and findings outlined in the abstract and introduction were clear in its premise and throughout the paper.

The introduction and background were able to explain common techniques such as Space Filling Curves (SFC) and sorting algorithms to load balance these types of applications in such a way that someone who has no experience in these types of problems, such as myself, is able to understand from a high-level perspective. Everything presented is logically organized; it builds up the information as the reader progresses. There was no portion of the paper that over-explained or was not descriptive enough – each section had a meaningful purpose.

The contribution is relatively simple yet yields a fairly decent performance gain for the amount of work required. The algorithm is well documented and experimental setup is sufficient enough for reproducibility. Overall, the paper is good as it stands and should be accepted.

Summary of the Paper and Assessment

Load balancing typically correlates to balancing the amount of compute of a given job. This paper shows that performance can be gained by partitioning based on minimizing communication despite unequal compute partitioning. For applications such as Adaptive Mesh Refinement (AMR), where every subregion must communicate with its neighbors on every iteration, the kernel is often times negligent compared to communication. It is critical to partition the problem in such a way that neighboring subregions are physically close to each other to minimize latency. A direct effect of minimizing latency is a faster time-to-solution and energy savings.

Within the HPC community, Space Filling Curves (SFC) are a common method for partitioning data. SFC are capable of mapping high-dimensional coordinates onto a 1D curve, which is used to represent processes, threads, or memory. With AMR problems, the goal of SFC are to order the mapped coordinates with respect to locality. This approach relies on the underlying sorting algorithm to load balance. Application and architecture specs regarding communication are not considered and do not affect the ordering.

The contribution of this research is the performance model used to direct the ordering of locality. It takes into account the network bandwidth, RAM bandwidth, data size, and work size. This model is used in the proposed algorithm, OptiPart, which is the same as distributed TreeSort, but instead uses the performance model to dictate refinements to the ordering.

Performance evaluation was conducted on Titan, Stampede and a CloudLab testbed: an 18688, 6400, and 8-node cluster, respectively. In all instances, OptiPart outperformed SampleSort by roughly 22%. Subsequently, a 22% gain in energy savings is achieved by using OptiPart. The graphics show that compute time is roughly the same, but communication is minimized by roughly 20%, implying that these algorithms are communication-bounded.

Not knowing what or how SFC are used in HPC, the paper gave an easy-to-read introduction on their purpose. The first third of the paper is almost entirely review of current methods and research regarding SFC and mapping AMR algorithms with respect to locality. The performance evaluation provided informative figures that showcased the 22% performance gain, and how exactly that was achieved.