SAND2021-10781R

SAND2021-xxxx C

Sandia National Laboratories

Operated for the United States Department of Energy
by National Technology and Engineering Solutions
of Sandia, LLC.

Albuquerque, New Mexico 87185-0351
Livermore, California 94551-0969

date: August 25, 2021

to: Rob Hoekstra (1420) (CSSE Sub-Program Lead)

from: Review Committee/Panel: Ron A. Oldfield, 1461 (Chair); Steven J. Plimpton, 1444; James H. Laros III, 1422; David Z. Poliakoff, 1422; and Andrew Sornborger, LANL

subject: Final Review of FY21 ASC CSSE L2 Milestone #7840 entitled "Neural Mini-Apps for Future Heterogeneous HPC Systems"

The final review for the FY21 Advanced Simulation and Computing (ASC) Computational Systems and Software Environments (CSSE) L2 Milestone #7840 was conducted on August 25th, 2021 at Sandia National Laboratories in Albuquerque, New Mexico. The review committee/panel unanimously agreed that the milestone has been successfully completed, exceeding expectations on several of the key deliverables.

Milestone Overview

As displayed in the FY21 ASC Implementation Plan (IP) and the Milestone Reporting Tool (MRT), the milestone description and completion criteria state:

> *A suite of key neuromorphic computing mini-apps with ASC relevance at scale will be developed and demonstrated on multiple existing neuromorphic platforms using a hardware-agnostic FUGU software stack.*
>
> *The mini-apps will include (two of the following):*
> - *Monte Carlo approximations of PDE solutions (Ref: Severa et al., IJCNN 2018; Smith et al., submitted ICONS 2020)*
> - *Deep artificial neural networks (Ref: Severa et al., Nat MI, 2019)*
> - *Neural graph analytics (Ref: Aimone et al., ICONS 2019; submitted ESA 2020)*
>
> *Platforms to be used for demonstration and evaluation include:*
> - *SpiNNaker board*
> - *Nahuku Bay Loihi (8-chip Loihi board)*
> - *TrueNorth (testbed at LLNL)*

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Exceptional Service in the National Interest
Page **1** of **3**

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Completion Criteria
1. *An initial release of two or more scientific computing mini-apps running on at least two neuromorphic processors*
2. *A comparative performance, scaling evaluation, and trade analysis of the mini-apps.*

Scope of Review

The milestone will be assessed through a kickoff meeting, mid-year, and final review by the committee. The final review package will include a presentation of results, a full report detailing execution of the milestone, and an executive summary.

Review Meetings

The kick-off meeting was conducted February 3rd, 2021.
The mid-year review was conducted May 5th, 2021.
The final review was conducted August 25th, 2021.

Feedback and Conclusions

On behalf of the review panel, we would like to congratulate the team for successfully completing the milestone. <u>The panel unanimously agrees that the team did an outstanding job executing the milestone as required in the milestone description</u> – exceeding expectations in the following ways:
- **Implementation of three mini-apps** (Random Walk, Sparse Coding, Graph Analysis). The milestone only required implementation of two of the three applications. The team did an excellent job of describing relevance of the applications to Sandia mission describing implementation challenges of each application.
- **Implementation in FUGU**. The committee was happy to see the team implement the mini-apps in FUGU even though that wasn't a requirement of the milestone. The committee also appreciated the discussion and presentation of FUGU examples in the briefing – this was a particular request from the mid-year review.
- **Presentation of performance results**. Although performance assessment was part of the completion criteria, the committee believes the team exceeded expectation in the level of detail presented in the performance analysis. The team clearly articulated the strengths and weaknesses of the algorithms and architectures and helped the committee understand nuances of performance in somewhat complex systems. In particular, the detailed discussion of the implication/capabilities of probes on the Loihi system was appreciated.

The committee commends the team for collaborating with LLNL on the TrueNorth system and agreed that focusing on Loihi and SpiNNaker for the milestone was a smart decision. The committee also appreciated the attention to detail and the effort made to address suggestions and requests made in the mid-year review, particularly the suggestion to expand the role of FUGU in the milestone. Finally, the committee agreed the milestone team did a nice job of identifying deliverables that clearly advance the direction of the neuromorphic computing research program at Sandia.

Recommendations

Although the team successfully completed the milestone, the committee had a few suggestions for future work. Given the progress on FUGU, it would be great to see FUGU implementations for more applications and for neuromorphic architectures besides Loihi. The premise that the FUGU provides an abstraction suitable for a variety of Neuromorphic computing architectures will certainly be tested through such an effort. The committee would also like to see comparisons to traditional implementations on conventional hardware as well as comparisons to some of the emerging data-flow architectures. Vanguard II program should provide opportunity for such analysis. The committee also believes that team should look for opportunities to brief the broader tri-lab community on the neuromorphic effort going on at Sandia.

Attendees of the final review:

       L2 Milestone Team
           James B. Aimone, 1421 (co-PI)
           Craig M. Vineyard, 1421 (co-PI)
           Suma Cardwell, 1421
           Frances Chance, 1421
           Ryan Dellana, 1421
           Zubin Kane, 1421
           Sarah Luca, 1421
           Srideep Musuvathy, 1421
           Luke Parker, 1421
           Mark Plagge, 1421
           Fredrick Rothganger, 1421
           William Severa, 1421
           Darby Smith, 1421
           Corinne Teeter, 1421
           Felix Wang, 1421

       Review Committee/Panel
           Ron A. Oldfield, 1461 (Chair)
           Steven J. Plimpton, 1444
           James H. Laros III, 1422
           David Z. Poliakoff, 1422
           Andrew Sornborger, LANL

       Other
           Rob Hoekstra, 1420 (CSSE Sub-element lead)
           John Feddema, 1460
           John Wagner, 1421

Commented [ORA1]: John W., which of these should be listed as part of the team milestone team? I assume Darby and Felix. Were there others that contributed to the milestone?