Using Coroutines to Support Accelerators in TTG

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Discussion on programming models risks and benefits

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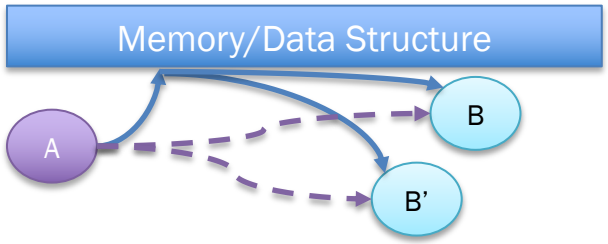
Composition Granularity

Backward-looking models

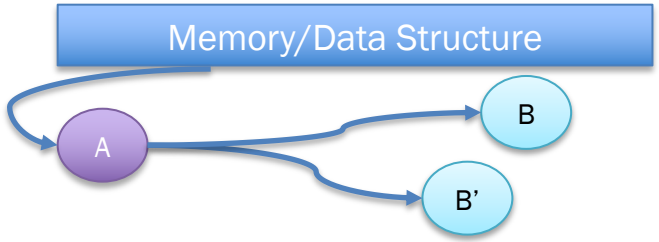
- Based on integration points:
  - Data structures (StarPU, Legion)
  - Memory locations (OpenMP, OmpSs)
  - Futures/promises (HPX, C++)
- Task-wise composition:
  - Distributed data structures
  - Based on (*implicit*) contracts



Task B accesses some data and thus depends on Task A, who produced that data.

Forward-looking models

- Pure data-flow
- Task-graphs similar to functions:
  - Black-boxes with well-defined inputs & outputs
  - Computational structure known within
- Algorithms composed through Edges as integration points



Task A produces data and sends it to Task B, who consumes it.

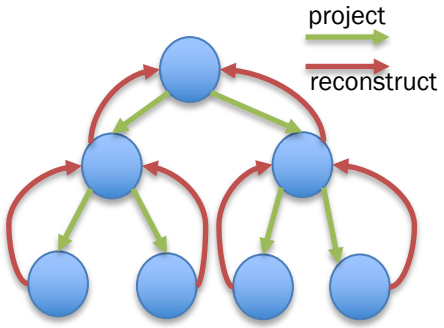
Target Applications

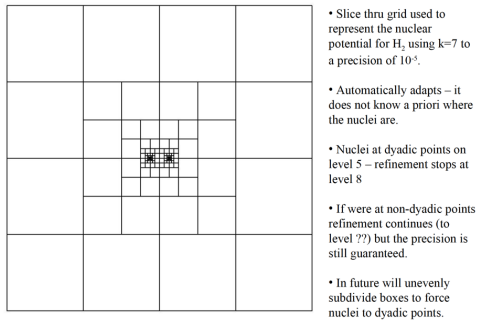
Block-sparse matrix algorithms for Sparse Tensor Algorithms in TiledArray

- Forwarding of tiles between operators
- Forking off tiles to preserve versions from subsequent changes
- Composition of operators
  - Merging basic operators in TA
  - Flow between operators

Multi-Resolution Function Analysis in MADNESS

- Tree traversal: refinement and reconstruction of functions in 3D/6D
- Central part of MADNESS
- Variable tree-depths, dynamic refinement
- No distributed data structure





- Slice thru grid used to represent the nuclear potential for H_2 using k=7 to a precision of 10^{-5}.
- Automatically adapts – it does not know a priori where the nuclei are.
- Nuclei at dyadic points on level 5 – refinement stops at level 8
- If were at non-dyadic points refinement continues (to level ??) but the precision is still guaranteed.
- In future will unevenly subdivide boxes to force nuclei to dyadic points.

Acknowledgements

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Resources

- ECP Tutorial: https://www.exascaleproject.org/event/ttg-2022/
- Paper:
  - J. Schuchart *et al.*, "Generalized Flow-Graph Programming Using Template Task-Graphs: Initial Implementation and Assessment," *2022 IEEE International Parallel and Distributed Processing Symposium (IPDPS).*
  - J. Schuchart, P. Nookala, T. Herault, E. F. Valeev and G. Bosilca, "Pushing the Boundaries of Small Tasks: Scalable Low-Overhead Data-Flow Programming in TTG," *2022 IEEE International Conference on Cluster Computing (CLUSTER).*
  - T. Herault, J. Schuchart, E. F. Valeev and G. Bosilca, "Composition of Algorithmic Building Blocks in Template Task Graphs," *2022 IEEE/ACM Parallel Applications Workshop: Alternatives To MPI+X (PAW-ATM).*
- Github: https://github.com/TESSEorg/ttg/

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