Mustafa Ozan Karsavuran

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Research Experience

I worked on achieving performance improvement in MPI based applications running on distributed-memory machines through reducing communication. I also worked on OpenMP based parallel sparse matrix and tensor computations on Xeon Phi accelerator and Xeon processor. I designed and implemented hypergraph partitioning (HP) models, including utilizing recursive bipartitioning (RB) paradigm.

Stochastic Gradient Descent (SGD) for Matrix Completion

- Scaling stratified SGD for distributed matrix completion 2022
  - ◇ Collaborated on point-to-point (P2P) communication scheme and related hold-and-combine algorithm
  - ◇ Implemented a computational load balancing method and an HP model which minimize the communication volume
  - ◇ Obtained about up to 15× faster parallel runtime and submitted the results to IEEE TKDE
- Reducing stale data usage and bandwidth requirement in SGD 2022
  - ◇ Contribute on the design of the MPI-based SGD with sub-iterations
  - ◇ Design and implement an HP model minimizing both staleness and bandwidth requirement in SGD
  - ◇ Obtained up to 34% reduction in parallel runtime and submitted the results to IEEE TC
- Hybrid Parallel SGD 2022
  - ◇ Contribute on the design and implementation of the MPI+POSIX threads based hybrid parallel SGD
  - ◇ Obtained up to 6× better throughput and the results will be submitted to Journal of Systems and Software soon

Parallel Sparse Tensor Decomposition

- Hiding latency of the sparse P2P communications into dense all reduce communications 2021
  - ◇ Collaborated on reorganizing the CPD algorithm for embedding P2P messages into ALLREDUCE messages
  - ◇ Designed and implemented an HP model which minimizes the concurrent communication volume in the embedded ALLREDUCE
  - ◇ Scaled CPD on up to 4096 processors and published the results in IEEE TPDS
- General medium-grain sparse tensor partitioning for distributed CPD 2019
  - ◇ Designed and implemented an HP model for medium-grain partitioning without any topological constraint
  - ◇ Utilized RB paradigm to boost performance at each level of the partitioning
  - ◇ Conducted experiments with 10 real-world tensors on 1024 cores and published the results in IEEE TPDS
- Locality-aware fiber and slice reordering for shared-memory MTTKRP 2017
  - ◇ Implemented an HP model for reordering fibers and/or slices of tensors for increasing cache locality during MTTKRP
  - ◇ Adopted SPLATT's OpenMP based MTTKRP and conduct experiments

Large Scale Benchmarking

- Code owner of the NEMO package in the PRACE-6IP T7.4.A activity 2021
  - ◇ Prepared architecture specific build files for both NEMO and XIOS packages for six tier-0 HPC systems
  - ◇ Benchmarked the NEMO and XIOS on HAWK, TGCC Joliot Curie, JUWELS, Marconi100, MareNostrum and SuperMUC-NG using up to 10,000 cores
  - ◇ Contribute to the deliverable PRACE-6IP-D7.4: Evaluation of Benchmark Performance

Sparse Matrix Vector Multiplication (SpMV) and Sparse Matrix Dense Matrix Multiplication (SpMM)

- Latency balancing and minimization for reduce operations 2020
  - ◇ Design and implement a novel cutsize metric to minimize the maximum message counts
  - ◇ Modified an existing MPI-based SpMV implementation into SpMM
  - ◇ Conduct experiments to show the validity of the proposed models
- Volume balancing and latency minimization for reduce operations 2018
  - ◇ Formulate a novel vertex weighting scheme for the HP model which balance volume loads of processors
  - ◇ Implement a refinement algorithm called during the RB and decrease the increase in the communication volume
  - ◇ Perform extensive experiments on 512 processors for 70 matrices
  - ◇ Obtain 30% faster parallel runtime in column-parallel SpMV and published in IEEE TPDS
- Locality-aware shared-memory parallel $y \leftarrow AA^Tx$ on many-core processors 2014
  - ◇ Implement OpenMP-based $y \leftarrow AA^Tx$ which achieve reusing A-matrix nonzeros and vector entries
  - ◇ Conduct detailed experiments on Intel Xeon Phi co-processor running in offload mode
  - ◇ Obtain 20% reduction in parallel runtime and published in IEEE TPDS

Other Hypergraph Partitioning Models

- Simultaneous computational and data load balancing of the processors on distributed-memory setting 2022
  - ◇ Collaborated on design of two-constraint HP models which encodes computational and data load simultaneously
  - ◇ Collaborated on experiments with two different applications and published the results in SIAM J. Sci. Comput.
- Worked on various HP models (such as cartesian and jagged partitioning) for partitioning sparse matrices and tensors

Generalized Sparse Matrix Matrix Multiplication (SpGEMM)

- Efficient Vectorization of SpGEMM 2016
  - ◇ Transform an $C = ADB$ instance into $C = Zd$ SpMV instance by multiplying A-matrix with B-matrix columns
  - ◇ Implement efficiently vectorized OpenMP based $C = Zd$ using AVX instructions
  - ◇ Conduct experiments on Intel Xeon Phi co-processor and Xeon processor

Experience

Postdoctoral Researcher — September 2020 – *present*
Bilkent University — Ankara, Turkey

Teaching and Research Assistant — September 2012 – June 2020
Bilkent University — Ankara, Turkey

Education

Bilkent University, Dept. of Computer Engineering, Turkey

- **Doctor of Philosophy** GPA: 3.47/4.00 — September 2014 – August 2020
  Thesis: Reducing Communication Overhead in Sparse Matrix and Tensor Computations
  Advisor: Prof. Dr. Cevdet Aykanat
- **Master of Science** GPA: 3.60/4.00 — September 2012 – September 2014
  Thesis: Increasing Data Reuse in Parallel SpMV and SpMTV Multiply on Shared-Memory Architectures
  Advisor: Prof. Dr. Cevdet Aykanat
- **Bachelor of Science** GPA: 3.44/4.00 — September 2007 – June 2012

Journal Publications

- N. Abubaker, O. Çağlayan, **M. O. Karsavuran** and C. Aykanat, "Minimizing Staleness and Communication Overhead in Distributed SGD for Collaborative Filtering" in IEEE Transactions on Computers, *under review*
- N. Abubaker, **M. O. Karsavuran** and C. Aykanat, "Scaling Stratified Stochastic Gradient Descent for Distributed Matrix Completion," in IEEE Transactions on Knowledge and Data Engineering, *under major revision.*
- M.F. Çeliktuğ, **M. O. Karsavuran**, S. Acer and C. Aykanat, "Simultaneous Computational and Data Load Balancing in Distributed-Memory Setting," in SIAM Journal on Scientific Computing, *accepted.*
- N. Abubaker, **M. O. Karsavuran** and C. Aykanat, "Scalable Unsupervised ML: Latency Hiding in Distributed Sparse Tensor Decomposition," in IEEE Transactions on Parallel and Distributed Systems, vol. 33, no. 11, pp. 3028-3040, 1 Nov. 2022. doi: 10.1109/TPDS.2021.3128827
- **M. O. Karsavuran**, S. Acer and C. Aykanat, "Partitioning Models for General Medium-Grain Parallel Sparse Tensor Decomposition," in IEEE Transactions on Parallel and Distributed Systems, vol. 32, no. 1, pp. 147-159, 1 Jan. 2021. doi: 10.1109/TPDS.2020.3012624
- **M. O. Karsavuran**, S. Acer and C. Aykanat, "Reduce Operations: Send Volume Balancing While Minimizing Latency," in IEEE Transactions on Parallel and Distributed Systems, vol. 31, no. 6, pp. 1461-1473, 1 June 2020. doi: 10.1109/TPDS.2020.2964536
- **M. O. Karsavuran**, K. Akbudak and C. Aykanat, "Locality-Aware Parallel Sparse Matrix-Vector and Matrix-Transpose-Vector Multiplication on Many-Core Processors," in IEEE Transactions on Parallel and Distributed Systems, vol. 27, no. 6, pp. 1713-1726, June 1 2016. doi: 10.1109/TPDS.2015.2453970

Talks

- Medium-Grain Partitioning for Sparse Tensor Decomposition, SIAM CSE21, Virtual, 2021.

Funded Projects

- **A Flexible Store-And-Forward Communication Framework For Scaling Latency-Bound Parallel Programs**
  TUBITAK 1001 - 121E391, Postdoctoral researcher — February 2022 – *present*
- **Parallel Stochastic Gradient Descent Algorithms for Large-Scale Recommendation Systems**
  TUBITAK 1001 - 119E035, PhD student and Postdoctoral researcher — October 2019 – February 2022
- **Benchmarking (UEABS)**
  PRACE-6IP T7.4.A, Benchmark code owner (with Prof. Dr. Cevdet Aykanat) for NEMO package — May 2019 – December 2021
- **High Performance Tensor Decomposition Methods For Distributed and Shared Memory Parallel Systems**
  TUBITAK 1001 - 116E043, PhD student — November 2017 – October 2019
- **Peta-scaling Sparse Iterative Solvers via Optimizing Multiple Communication Metrics**
  International COST - 114E545, PhD Student — May 2015 – September 2017

Technical Skills

Advanced in: C, C++, MPI, OpenMP
Familiar with: CUDA, Python, Java SE, C#, MATLAB, Assembly (MIPS and Intel 8051), PHP, SQL

Professional Service

- **Reviewer** in PPAM22 (14th International Conference on Parallel Processing and Applied Mathematics)
- **Reviewer** in BAŞARIM 2020 (6. Ulusal Yüksek Başarımlı Hesaplama Konferansı / 6th National Conference on High Performance Computing)
- **Reviewer** in IPDPS 2018 (31st IEEE International Parallel & Distributed Processing Symposium)

Honors and Awards

Design Award for Senior Design Project from Bilkent University	2012
100% Merit Scholarship from Bilkent University	2010 – 2012
Ranked as 1st at III. Dokuz Eylül University Science and Engineering Project Contest	2006
Ranked as 2nd in TÜBİTAK National Project Contest for High School Students	2006