

# 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.

### Sparse Symmetric Indefinite Matrix Factorization

- Right-looking sparse  $A = LDL^T$  factorization 2023
  - ◊ Work in progress

### 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  $15\times$  faster parallel runtime and published the results in 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  $6\times$  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  $y \leftarrow AA^T x$  on many-core processors 2014
  - ◊ Implement OpenMP-based  $y \leftarrow AA^T x$  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 Scholar

Lawrence Berkeley National Laboratory

November 2022 – *present*

Berkeley, California, U.S.

### Postdoctoral Researcher

Bilkent University

September 2020 – October 2022

Ankara, Turkey

### Teaching and Research Assistant

Bilkent University

September 2012 – June 2020

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

- K. Büyükkaya, **M. O. Karsavuran** and C. Aykanat, “Stochastic Gradient Descent for Matrix Completion: Hybrid Parallelization on Shared- and Distributed-Memory Systems” in Knowledge-based Systems, *under revision*
- 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 major revision*
- 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, *accepted*. 10.1109/TKDE.2023.3253791.
- M.F. Çeliktug, **M. O. Karsavuran**, S. Acer and C. Aykanat, “Simultaneous Computational and Data Load Balancing in Distributed-Memory Setting,” in SIAM Journal on Scientific Computing, vol. 44, no. 6, pp. C399-C424, 1 Nov. 2022. doi: 10.1137/22M1485772.
- 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

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- **Reviewer** in CCPE (Concurrency and Computation: Practice and Experience)
- **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

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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

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